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CONTENTS

CONTRIBUTIONS, ABSTRACTS, AND BIBLIOGRAPHY

WEATHER OF THE MONTH

CHARTS

† In marine separate.

CORRECTIONS

REVIEWS, December, 1924, and January and February, 1925: In the Table of Contents, second column, under heading "Charts," omit the words "not charted" after Chart VII.

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AN ACCOUNT AND ANALYSIS OF THE MEISINGER FREE-BALLOON FLIGHTS

By V. E. JAKL

[Weather Bureau, Washington, March, 1925]

The main purpose of the flights made by the late Dr. C. LeRoy Meisinger can be best expressed by quoting from some of his correspondence on the subject, in which he proposed that the flights be undertaken by him for the Weather Bureau, in cooperation with the Army Air Service. The following is an extract from one of his memoranda:

> We now have at our disposal the machinery for making free-air pressure maps, and the one big problem in connection with them is to learn to interpret them. Can we have confidence in them in deriving the "life history" of free-air currents? The free balloon (manned) furnishes the only means of obtaining an observation upon the path of air moving in response to given pressure gradients. Except for convection induced by thermal inequalities, the air probably has but small vertical component even when being forced aloft by "wedges" of cold air.

It may be opportune here to say that this expedition was the consummation of an enterprise that Doctor Meisinger had advocated and repeatedly striven to undertake for a number of years. The inception of the idea in his mind may be said to date back to the post-war days of his service as lieutenant and meteorological officer in the balloon school of the Army Air Service at Fort Omaha, Nebr. On April 16–17, 1919, while at Fort Omaha, he took part as one of the pilots in a constant-altitude flight made with two balloons taking off at the same time, but flying at different altitudes. This flight was the first experiment at maintaining a balloon at constant altitude in which he participated, and proved very interesting to him from a meteorological standpoint. In his description and analysis of the flight, which appeared in the August, 1919, number of the MONTHLY WEATHER REVIEW, **47:** 535–538, he concludes with the following paragraph:

> It is obvious that the data obtained in a single attempt of this kind are too meager to be the foundation of any theoretical work. Nevertheless, a large number of such observations, where an attempt to maintain a constant elevation is strictly adhered to, would certainly contribute to our knowledge of the motion of air about centers of high and low pressure.

As a trained balloon pilot and keen meteorologist, it was natural that after his entry into the Weather Bureau he should have felt the urge to carry on the work suggested to him by his Army experience, as an important aid to meteorology. A further incentive to undertake these flights was his concern over problems connected with practical interpretation of his laborious work on upper-air pressure reduction, the results of which were published in his monograph on "The Preparation and Significance of Free-Air Pressure Maps for Central and Eastern United States" (MONTHLY WEATHER REVIEW SUPPLEMENT No. 21). As already quoted from him, he saw in the proposed flights a means to prove the trustworthiness of his upper-air pressure maps, and thereby to inspire confidence in their use. A comprehensive outline of the history, aims and purposes of the project, and program of work laid out for carrying it through, was given by Doctor Meisinger in an article that appeared in the MONTHLY WEATHER REVIEW for January, 1924, **52:** 27–29, under the caption, "The Balloon Project and What We Hope to Accomplish."

The flights, 10 in all, were made from Scott Field, near St. Louis, Mo., during the period from April 1 to June 2, 1924. In each flight the balloon was manned jointly by Doctor Meisinger and by Lieut. James T. Neely of the Army Air Service, who served in the capacity of co-pilot in all but the first flight. The choice of time for these flights arose from Doctor Meisinger's conviction that spring would be most propitious. In this connection he wrote: "But I am convinced that flights of 18 to 24 hours and even longer could be made at approximately constant elevations under conditions in which ordinary convection currents are not active, and such times are frequent in early spring."

It developed that the character of the weather in the spring of 1924 proved unfavorable for carrying out his project to the degree of fulfillment that he had hoped for. In many respects the weather maps had the characteristics of summer, i. e., ill-defined pressure systems, unsettled weather, thunderstorms, and considerable convectional activity at various times. There were therefore few conditions that were ideal for his purpose, while the very conditions he hoped to avoid in his choice of time of year for the flights were predominant. It is a tribute to his zeal and to the courage of both pilots that, having embarked on the project, it was carried through in spite of difficulties and repeated dangerous conditions.

Under the circumstances the project for the most part fell short of achieving the main results sought. From an interpretation of the logs and records it is apparent that in only a minority of the flights was anything approximating constant altitude for a considerable distance realized. Much of the value of the records was of course lost with his death, for with his competence and absorption in the subject, coupled with his experience in making the flights, he would have made certain interpretations of many features of the records, that are only a matter of conjecture to others. From a general appraisal of the work, it is apparent to the writer, that so far as it has been possible to compare the paths of the flights with appropriate upper-air isobars, the verification of the accuracy of the Meisinger upper-air pressure reduction method was accomplished.

Whether the flights justified Doctor Meisinger's faith in the free-balloon as a means of demonstrating free-air

trajectories, is a matter that does not easily lend itself to an unqualified answer, principally because, under the generally unfavorable weather, the possibilities of free-ballooning to that end were not given a fair test. The delineation of upper-air trajectories is an extremely difficult thing to approach from any method of observation. In addition to the well-nigh insurmountable difficulty of maintaining a free-balloon at a constant altitude for any prolonged period, considerations of vertical component of air movement obviously enter into the problem. A possible underestimation of the factor of vertical movement by Doctor Meisinger is apparent in the paragraph from him already quoted that "except for convection induced by thermal inequalities the air probably has but small vertical component, etc." Whether or not he underestimated this phase of the problem depends of course on his conception of "small vertical component." However, an instance appears in the first flight, in which, if the conclusions of the writer are correct, the course of the balloon did not represent an air trajectory throughout its length, even though the balloon flew at an approximately constant altitude and closely followed the upper-air isobars. An analysis of this flight is given below, and this is followed in turn by a discussion of all the remaining flights in the order in which they were made.

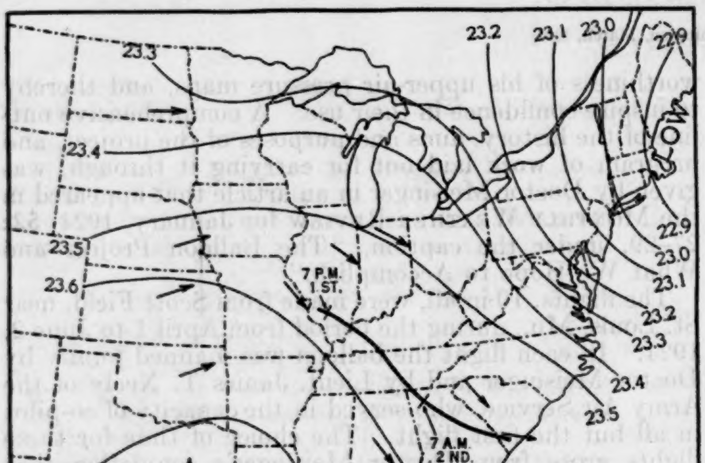

FIG. 1.—Pressure distribution and wind direction at 2 kilometers above sea level, 8 a. m., 75th meridian time, April 2, 1924. Balloon path in heavy line

First flight—April 1, 5:27 p. m., 90th meridian time, to April 2, 5:10 p. m., 75th meridian time. Landing, near Walterboro, S. C., 680 miles from starting point. The balloon's path is plotted on figures 1 and 2, which show the isobars at 2,000 meters, and the surface isotherms and sea level isobars, respectively, for 7 a. m., April 2. The 7 a. m. observation of the 2d has been selected as best representing the accompanying sea level and 2,000-meter pressure distribution, inasmuch as this time falls about midway of the flight, and the upper-air pressure reduction tables are based on the a. m. observations only. Arrows indicate wind directions at 2,000 meters, derived from pilot balloon observations taken on the morning of the 2d.

The close coincidence of the balloon path with the 2,000-meter isobars is at once apparent, although the balloon actually traveled at an altitude somewhat greater than 2,000 meters during a large portion of the time. Attention is next directed to the temperatures observed during the flight, a record of which appears in Table 1. The rise after 1:35 a. m. is noteworthy in view of its bearing on the problem of air trajectory. Possibly erroneous temperature readings might be assumed from the circumstance of approaching dawn and effect of sunlight on balloon and instrument. Temperature observations were made by means of a nickeled Assmann psychrometer suspended by a cord about 15 feet below the basket. However, the rise is already apparent in the readings at 1:35 a. m. and 4:20 a. m., by comparing them with interpolated readings at corresponding altitudes in the early part of the flight. Moreover, an original note appears on the meteorogram at 2 a. m. reading, "Temperature rise about 1.3° C," in explanation of a sudden short rise in the altitude of the balloon. (See fig. 3.) It should also be noted that the low temperatures recorded in the first few hours of the flight were likewise observed while the sun was above the horizon. It must therefore be concluded that at least the greater part of the observed rise in temperature was

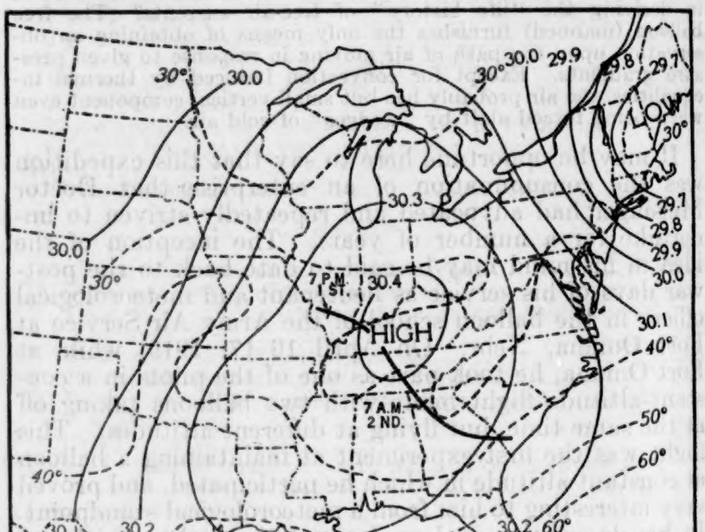

FIG. 2.—Pressure distribution at sea level and surface isotherms, 8 a. m., 75th meridian time, April 2, 1924. Balloon path in heavy line

real. This implies a state of stable equilibrium of the air, or a small lapse rate within the HIGH that was overlying the southeastern states on the morning of the 2d. By noting the displacement of the HIGH toward the west at 2,000 meters, as compared with its position on the surface map, it is apparent that comparatively low temperatures in the lower levels over the eastern states contributed largely toward determining the position of the HIGH on the surface, and that temperatures aloft over the southeastern states were probably not much lower than at the surface. It is evident then that a warmer region was encountered by the balloon at the altitudes in which it flew while passing from the Missouri Valley to South Carolina.

TABLE 1.—*Temperatures observed in the balloon flight of April 1–2, 1924*

Time, 90th meridian	Altitude		Temperature	
	Feet	Meters	°C.	°F.
Apr. 1				
5:27 p. m. (surface)	471	143	4.0	39.2
6:27 p. m.	2,000	610	−4.8	23.4
8:00 p. m.	4,000	1,219	−10.0	14.0
9:06 p. m.	6,000	1,829	−10.0	14.0
9:39 p. m.	7,100	2,164	−10.0	14.0
12:00 midnight	7,100	2,164	−10.0	14.0
Apr. 2				
1:35 a. m.	6,400	1,951	−8.7	16.3
4:20 a. m.	5,600	1,707	−6.5	20.3
5:27 a. m.	5,200	1,585	−4.3	24.3
6:25 a. m.	7,300	2,225	1.2	34.2
8:50 a. m.	8,700	2,652	3.4	38.1
11:47 a. m.	7,600	2,316	5.0	41.0
1:30 p. m.	6,000	1,829	10.0	50.0
4:10 p. m.	Sea level		[1] 15.0	59.0

[1] Interpolated from diurnal maximum temperature readings at Charleston and Savannah.

The air in which the balloon flew after leaving Scott Field evidently had a downward component. Further evidence of this appears in the record of the kite observation at Due West on the 1st, which shows a falling temperature at 1,500 meters; also in note of the fact that the temperature over Scott Field, 14° F., at 4,000 meters on the 1st, was potentially very nearly the same as the surface temperature, 42° F., at Savannah at the a. m. observation of the 2d. The inference is strong that a representation of the trajectory of air aloft from Scott Field to South Carolina on the 1st–2d, would be a three-dimensional one, and therefore impossible of deduction from direct observation.

In this connection it may be noted that under certain conditions a mass of cold air aloft may be transported considerable distances southward without material increase in temperature resulting. As a matter of comparison, citation is made of the records of Due West on March 10, 1924 (see Free-Air Summary, MONTHLY WEATHER REVIEW, March, 1924, **52:** 173), wherein such a transport of cold air over a long north-south route is shown. The difference is to be found in the fact that on March 10 cold air simply displaced the warmer air in front of it to a considerable height above the ground in the rear of an intense LOW, where presumably the same configuration of isobars prevailed within the vertical limits of observation; while on April 1–2 the cold air aloft moved in a path that was more or less transverse to the isobars in the lower levels, and therefore undoubtedly had a downward component as it drifted southeastward.

Second flight.—April 11, 2:40 p. m., to April 12, 2:35 p. m., 90th meridian time. Landing, at Palmyra, Ontario, 470 miles from starting point. The flight was made at various altitudes ranging from a few hundred feet to about 4,500 feet, or an average of from 2,500 to 3,000 feet. The meteorogram shows that a constant altitude was maintained only in the comparatively short period from 2 a. m. to 5 a. m. on the 12th, when the balloon was kept at equilibrium very close to 2,100 feet. The path of the balloon was in the form of an arc, the drift being successively toward the NNE., NE., and ENE., at an average speed of about 18 miles per hour. The chief point of interest in this flight is that notwithstanding the staggered record of altitude shown by the meteorogram, the path of the balloon coincides very closely with the isobars drawn for the 1,000 meter pressures at 7 a. m., of the 12th, computed by the Meisinger method. This coincidence is all the more remarkable in view of the fact that, as in the flight of April 1–2 the upper-air map with which comparison is made represents the pressure distribution only for a moment about midway of the time elapsed during the flight, during which period the surface pressure underwent noticeable changes. The p. m. map of the 11th in particular shows a marked divergence of the sea-level isobars from those representing the 1,000 meter pressures at 7 a. m., on the 12th. This flight as well as that of April 1–2, seems to give evidence that a certain stability of upper-air pressure conditions, compared with changes on the ground, prevails during periods when surface pressure gradients are not very pronounced. The surface and 1,000-meter isobars at 7 a. m. of the 12th, together with the path of the balloon, are reproduced in figure 4.

Third flight.—April 18, 7:35 p. m. to April 19, 5:50 a. m., 90th meridian time. Landing, at Lebanon, Tenn. In a few hours' steady rise after the take-off, an altitude of about 8,000 feet was attained, at which point it was discovered that the balloon was leaking. Descent was then made to 1,500 feet and effort made to maintain that altitude for the remaining few hours of the flight. Owing to the nature of the record, due to the behavior of the balloon, it has not been thought of sufficient value for further discussion.

FIG. 3.—Meteorogram of balloon flight of April 1–2, 1924

NOTE.—Key to references to original notes appearing on meteorogram: *a* "Settling owing to nocturnal cooling (no ballast thrown)"; *b* "Temperature rise about 1.3° C."; *c* "Sunrise"; *d* "Equilibrium maintained without valving during day"; *e* "Estimated top of haze layer"; *f* Descent suddenly accelerated, apparently because of cooling after passing below top of haze layer."

Fourth flight.—April 23, 5 p. m., to April 24, 2:50 p. m., 90th meridian time. Landing made at Navarino, Wis., 426 miles from starting point. A brief account of this flight is given in the MONTHLY WEATHER REVIEW for April, 1924, **52**:214–216, in connection with a description of the National Balloon Race from San Antonio, Tex. During that portion of the flight extending in an arc from Scott Field to the point on Lake Michigan where, at about 8 a. m., the balloon turned to the west, a fairly constant altitude averaging 1,600 feet above ground was maintained, after which variable winds with

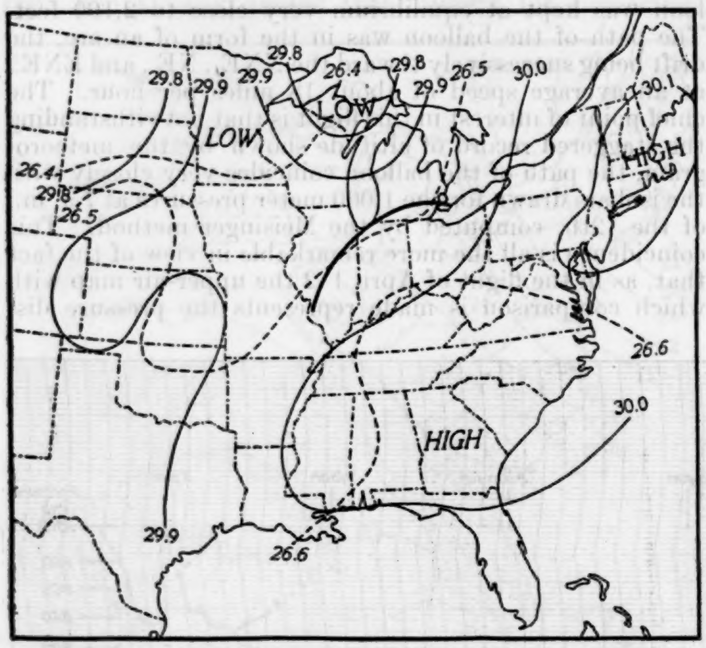

FIG. 4.—Pressure distribution at sea level and 1 kilometer above sea level, 8 a. m., 75th meridian time, April 12, 1924. Solid lines are sea level isobars; dashed lines are 1 kilometer isobars; and heavy line balloon path

threatening weather were encountered, and to maintain a constant altitude was no longer possible. This moderate altitude is that at which ordinarily "gradient winds" occur—i. e., winds paralleling the surface isobars. However, the first part of the arc shows a well-defined outflow from the HIGH situated to the east, and the latter portion a pronounced inflow toward a northern extension or reinforcement of the HIGH, where surface temperatures were lower. While pilot-balloon observations showed the same arrangement of wind directions, the free-balloon flight proves as an actual trajectory what the pilot-balloon observations show merely as an instantaneous line of flow. A further verification of this trajectory is given in the record of temperatures, which shows a quite constant temperature of about 15° C. throughout the constant altitude portion of the flight where the balloon was traveling northward. A later record of temperature made at about the same altitude, when the balloon was traveling westward, showed a much lower reading, indicating that at the point along Green Bay where the balloon was compelled to make an abrupt change in its altitude and course the trajectory changed to one having a pronounced ascending component. Figures 5 and 6 show in detail the path of the balloon and the surrounding sea level pressure for 7 p. m., 23d, and 7 a. m., 24th, respectively, the path of the balloon being reproduced on both charts. The 1,000-meter pressure map for 7 a. m., 24th (not reproduced), shows a close correspondence with the surface isobars at the same time.

Fifth flight.—April 29, 3 to 10 p. m., 90th meridian time. Landing, at Hartsburg, Mo., 130 miles nearly due west of starting point. A LOW was centered over Arkansas, and when the balloon took off, the surface wind was southwest at Scott Field and northeast at Columbia, Mo., 130 miles to the west. The flight was therefore made close to—and apparently ended directly at—the wind-shift line. A constant altitude of about 4,700 feet was maintained from 4 p. m. to 8 p. m. in an east-southeast wind. Owing to cloudy weather and precipitation, making the locating of the balloon's position difficult to the pilots, the course of the last two hours of the flight is uncertain, except that it is clearly evident that the descent from 9 to 10 p. m. was made in a northerly wind.

As the LOW was vigorous and moving, and as the flight was of short duration and length and near the time of the p. m. observation, it is obvious that no

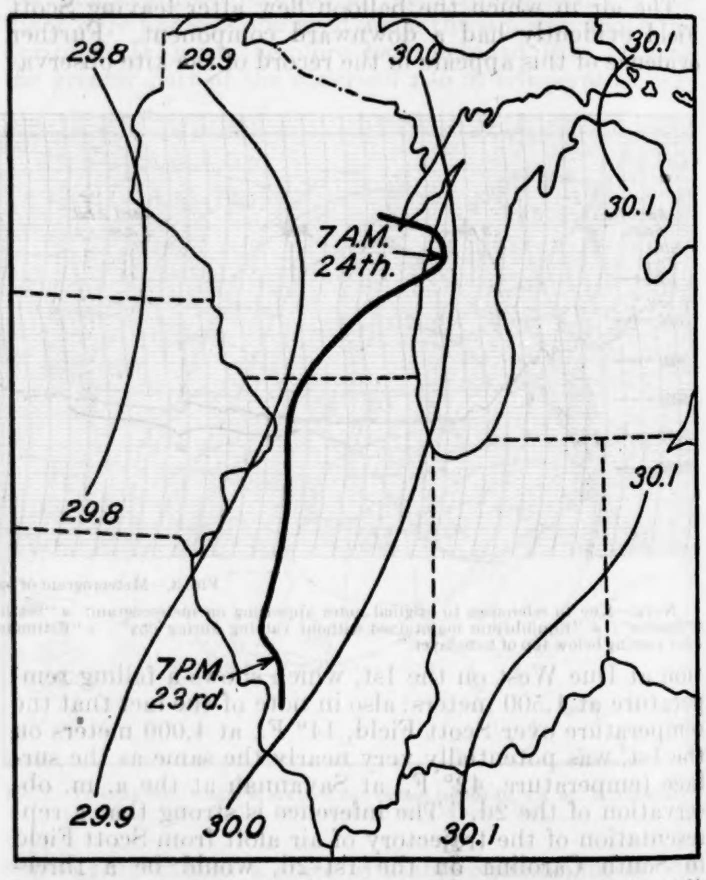

FIG. 5.—Pressure distribution at sea level, 8 p. m., 75th meridian time, April 23, 1924. Balloon path in heavy line

useful comparison is possible with upper-air maps. inasmuch as they apply to a. m. observations only, Interest in this flight is centered in the records of weather, temperature, and wind direction, and comparison of them with corresponding surface weather elements and changes therein. Making allowance for possible inaccuracy in outlining the path of the balloon, it is apparent from Figure 7 that the course lay either along the direction of the sea-level isobars, or deviated somewhat from them in the direction of higher pressure. General precipitation attended the LOW, and rain and snow were

encountered at intervals during the flight, the snow being observed in the occasional short ascents into higher altitudes where near-freezing temperatures prevailed. Rain became increasingly frequent as the balloon progressed westward, until at the western terminus of the flight steady rain compelled the decision to descend.

The temperature recorded was generally about 6° C. at the constant altitude of 4,700 feet, which compared with 13.3° C. on the ground at St. Louis at 7 p. m., shows

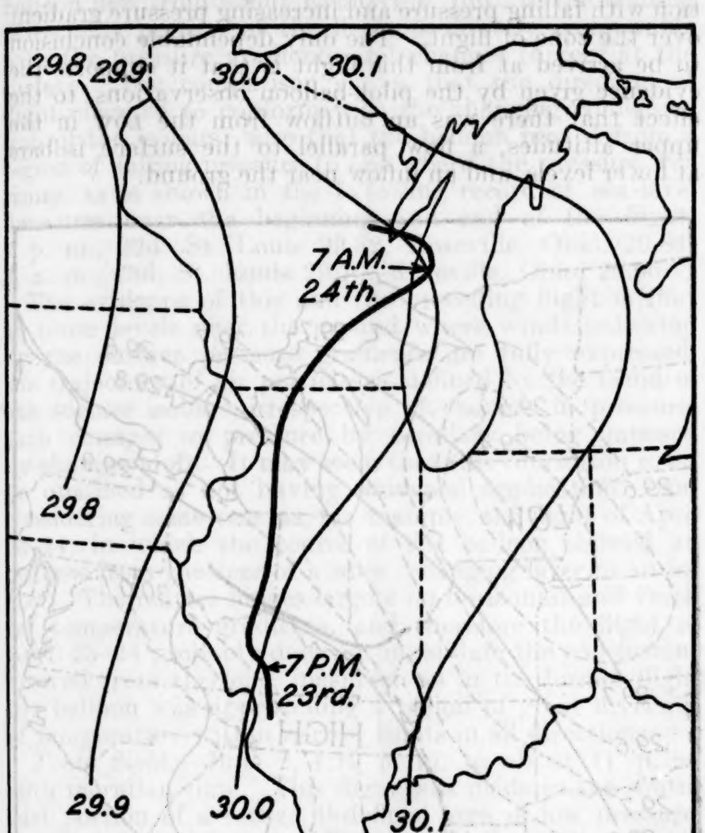

FIG. 6.—Pressure distribution at sea level, 8 a. m., 75th meridian time, April 24, 1924. Balloon path in heavy line

a lapse rate practically equal to the moist adiabatic for the given temperatures. This evidently represents the state of the air over that part of Missouri traversed by the balloon up to the time the wind shift occurred. From the fact that the surface wind became northerly at Columbia at 9 a. m., and at St. Louis soon after 8 p. m., it is clear that the last portion of the flight was made in an easterly wind underrun by one of increasing depth from a northerly direction, to which circumstance the precipitation in this portion of the LOW may be ascribed. The horizontal trajectory of air toward the west-northwest, represented by the constant altitude portion of the flight, unquestionably underwent a radical change at the point where the balloon was compelled to descend. It seems an inevitable conclusion that to whatever horizontal direction the trajectory continued, a strong vertical component applied.

Sixth flight. May 7, 5 p. m., to May 8, 2 a. m., 90th meridian time. Landing made at Henderson, Ky., 140 miles to the east-southeast of starting point. The meteorogram shows that in a gradual ascent of two hours an altitude of about 7,000 feet was attained, which with some variations of a few hundred feet, was maintained for about three hours. Following this brief period at constant altitude, the records show a more or less irregular descent lasting four hours. The flight was made in the rear of a low-pressure area that covered most of the eastern half of the country and caused general precipitation within its confines. As in the flight immediately preceding this one, rain and snow, tending to become continuous, compelled the descent. As nearly as can be ascertained from the log, the balloon drifted in a direction that varied from northwest-southeast in the lower levels to approximately west-east at the 7,000-foot altitude, the speed being somewhat greater aloft than near the ground. The nearest maps in point of time and altitude to which this flight can be referred are the sea level and 2,000-meter maps for 7 p. m., May 7, and 7 a. m., May 8, respectively. These show close agreement between the isobars and the path of the balloon at corresponding altitudes. Owing to the short distance (60 to 70 miles) at which a constant altitude was possible, neither the path of the balloon nor the maps applicable to it are reproduced.

The value of this flight, apart from what can be derived bearing on the main purpose of the project, lies in the somewhat unique upper-air data it furnishes. It represents an observation that, under similar conditions

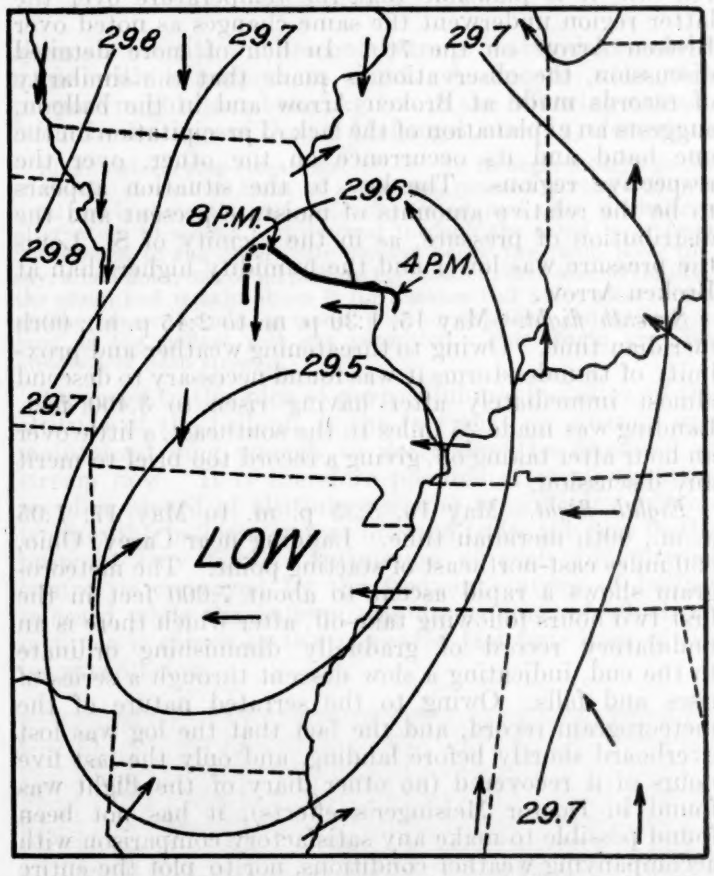

FIG. 7.—Pressure distribution at sea level and surface winds, 8 p. m., 75th meridian time, April 29, 1924. Balloon path in heavy line

of weather can not be wholly duplicated by ordinary methods of aerology, due to the limitations of kite and pilot-balloon observations during the prevalence of precipitation. An examination of the log shows that the balloon was repeatedly in and out of cloud banks that were encountered in various strata from about 2,500 feet altitude to as high as 8,000 feet. A rather complete record of temperature was taken during the ascent, and at frequent intervals while drifting at high altitude, the

main features of which appear to be a continuous fall in temperature with height. The reading of temperatures was terminated with loss of the recording instrument shortly before descent was begun.

The temperature at 7,000 feet at 7 p. m. was definitely 1.0° C., as it was substantiated by repeating readings at about the same altitude. At this time the balloon was only a short distance from Scott Field; therefore referring this reading to the simultaneous temperature at St. Louis, 14.4° C., a lapse rate more than the saturated adiabatic, and consequently active convection, is indicated. There is available for comparison a diurnal series of kite flights at Broken Arrow, 400 miles to the southwest, made on the 7th–8th. These observations show a gradually-increasing lapse rate on the 7th, due to falling temperature aloft in a northwesterly wind, until at 7 p. m. the temperature in a vertical direction was very nearly the same as that recorded by the balloon in the same range of altitude. The fall in temperature over Broken Arrow was attended by rising humidity, but not to any degree approaching saturation as was the case over the region near St. Louis. From the records of the sequence of events over Ellendale, Drexel, and Broken Arrow on the 6th–8th, and at the surface at St. Louis and contiguous territory on the 7th–8th, it is plausible that the temperature over the latter region underwent the same changes as noted over Broken Arrow on the 7th. In lieu of more detailed discussion, the observation is made that the similarity of records made at Broken Arrow and in the balloon, suggests an explanation of the lack of precipitation on the one hand and its occurrence on the other, over the respective regions. The key to the situation appears to be the relative amounts of moisture present and the distribution of pressure, as in the vicinity of St. Louis the pressure was lower and the humidity higher than at Broken Arrow.

Seventh flight.—May 15, 1:30 p. m. to 2:45 p. m., 90th meridian time. Owing to threatening weather and proximity of thunderstorms it was found necessary to descend almost immediately after having risen to 3,400 feet. Landing was made 25 miles to the southeast, a little over an hour after taking off, giving a record too brief to merit any discussion.

Eighth flight.—May 16, 5:35 p. m. to May 17, 7:05 a. m., 90th meridian time. Landing near Carey, Ohio, 390 miles east-northeast of starting point. The meteorogram shows a rapid ascent to about 7,000 feet in the first two hours following take-off, after which there is an undulatory record of gradually diminishing ordinate to the end, indicating a slow descent through a series of rises and falls. Owing to the serrated nature of the meteorogram record, and the fact that the log was lost overboard shortly before landing, and only the last five hours of it recovered (no other diary of the flight was found in Doctor Meisinger's effects), it has not been found possible to make any satisfactory comparison with accompanying weather conditions, nor to plot the entire course of the balloon with any precision.

The irregular nature of the altitude record can most plausibly be explained as due to difficulty in control of the balloon, possibly on account of a leak in the fabric, although no comment on the condition of the balloon appears in the log. In this connection, however, reference is made to an apparently similar situation in the early part of the next flight, in which note is made in the log that behavior of the balloon compelled descent to a lower altitude.

The flight was made in the region between a high pressure area over the southeastern States and a LOW centered in Ontario. By plotting the path of the balloon from the salvaged portion of the log, and assuming a straight line flight thence from starting point, it is apparent that the balloon flew in a moderate west wind at high altitudes in the evening and night of the 16th, and in very strong southwest winds at low altitudes in the morning hours of the 17th. This is in agreement with pilot-balloon observations, which, furthermore, show that the upper-air winds, particularly in the lower levels, increased in force from the 16th to 17th in connection with falling pressure and increasing pressure gradient over the zone of flight. The only dependable conclusion to be arrived at from this flight is that it supports the evidence given by the pilot-balloon observations, to the effect that there was an outflow from the LOW in the upper altitudes, a flow parallel to the surface isobars at lower levels, and an inflow near the ground.

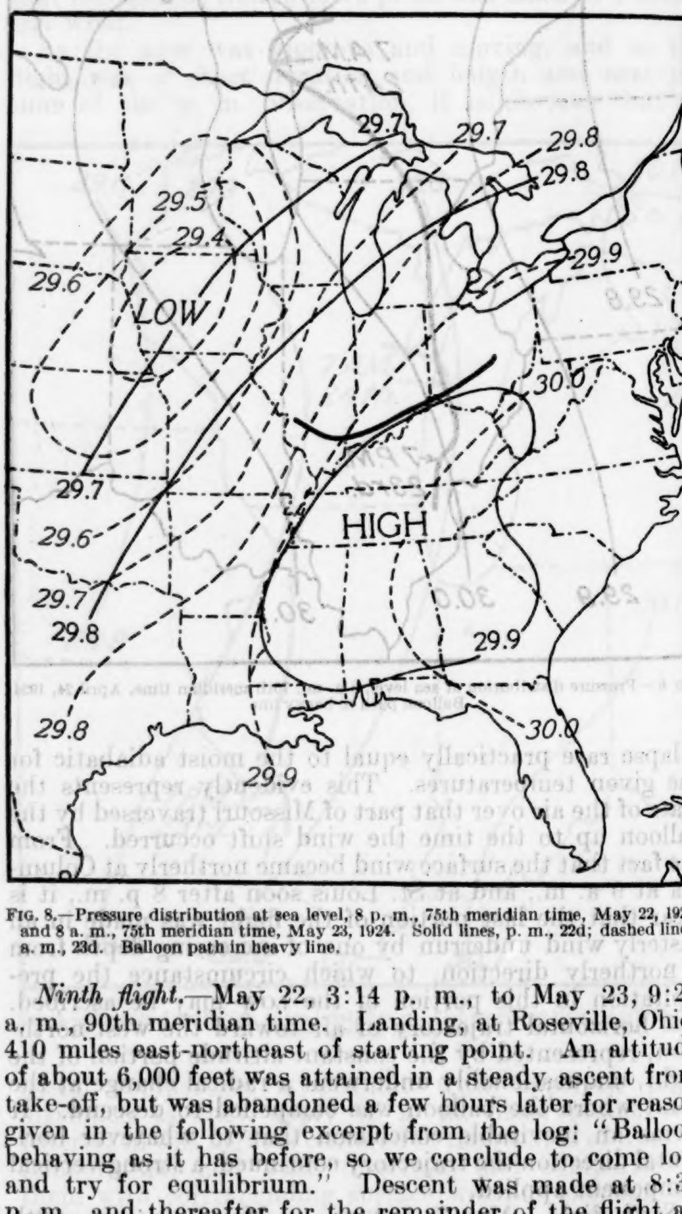

FIG. 8.—Pressure distribution at sea level, 8 p. m., 75th meridian time, May 22, 1924, and 8 a. m., 75th meridian time, May 23, 1924. Solid lines, p. m., 22d; dashed lines, a. m., 23d. Balloon path in heavy line.

Ninth flight.—May 22, 3:14 p. m., to May 23, 9:21 a. m., 90th meridian time. Landing, at Roseville, Ohio, 410 miles east-northeast of starting point. An altitude of about 6,000 feet was attained in a steady ascent from take-off, but was abandoned a few hours later for reason given in the following excerpt from the log: "Balloon behaving as it has before, so we conclude to come low and try for equilibrium." Descent was made at 8:30 p. m., and thereafter for the remainder of the flight an approximately constant altitude of about 1,300 feet was maintained. Threatening weather was encountered in the first few hours of the flight, notes of showers about and in the vicinity of the balloon and thunder in the distance being occasionally entered in the log. The balloon outran this threatening weather by nightfall, as no further entries of that nature appear in the log after late afternoon.

The balloon took a course about east-southeast in the short distance it traveled at a high altitude during the early part of the flight; and thereafter, at the low altitude in which the flight was completed, the course was about east-northeast, approximately conforming to the isobars in the rear of a HIGH that overlay the southeastern States. Figure 8 shows the sea-level isobaric lines at 7 p. m., 22d, and 7 a. m., 23d, and the path of the balloon. On account of the low altitude at which the balloon flew from about Evansville, Ind., to the landing place, this portion of the flight is directly comparable with the pressure gradients and changes therein at the surface. The comparison shows that the direction of flight changed to conform with the changing configuration of the isobars; also that the balloon moved from a region of falling pressure to one where the pressure was rising, as is shown in the following record of sea-level pressures near the beginning and end of the flight: 7 p. m., 22d, St. Louis 29.82, Roseville, Ohio, 29.84; 7 a. m., 23d, St. Louis 29.70, Roseville, Ohio, 29.96.

The evidence of this and the preceding flight is that at those levels near the ground where winds indicated by the surface pressure gradients are fully expressed, the trajectory of air particles is defined by the trend of the surface isobars, irrespective of changes in pressure, such changes in pressure by corollary being imposed by changes aloft. It may seem that this conclusion must be qualified as not having universal application, after considering some case, as, for example, the flight of April 23–24, in which the course of the balloon showed an outflow from the rear of a HIGH, changing later to an inflow. The matter hinges largely on horizontal and vertical temperature gradients, and therefore the flight of April 23–24 probably does not invalidate the conclusions derived from this one, inasmuch as in the former flight the balloon was approaching a region of great diversity of temperature within narrow limits in all directions.

Tenth flight.—June 2, 4:10 p. m. to about 11 p. m. 90th meridian time. This flight was made in the southeast portion of a rather ill-defined area of low pressure, centered near the upper Mississippi Valley. (See fig. 9.) The trajectory of the flight determined from the log shows a somewhat irregular course toward the north and northeast, but averaging about north-northeast, as shown by a line drawn from Scott Field to Monticello, Ill., 125 miles distant, near which town the balloon fell. The course was apparently directed more toward the east in the higher altitudes, in agreement with pilot-balloon observations made a few hours earlier. The balloon did not adhere to any certain altitude for more than a few minutes at a time, as the meteorogram shows that it rose and fell in a series of ascents to sucessively higher altitudes. (See fig. 10.) In each case the descent was made to almost exactly 600 feet above ground. This procedure in manipulating the balloon can hardly be attributed to threatening weather conditions on the assumption that each descent was made as a precaution against recurrent dangerous conditions. The only mention found in the log of threatening or dangerous weather is at 9:10 p. m., where the following entry appears: "Occasional lightning flashes in distance." That this observation gave the pilots no concern as to its possible portent is indicated by the fact that immediately following this entry, which was made at low altitude, the balloon was allowed to rise again to a high altitude.

The regularity with which a certain altitude was reached on each descent suggests that the balloon was under control at all times until the end, and that the

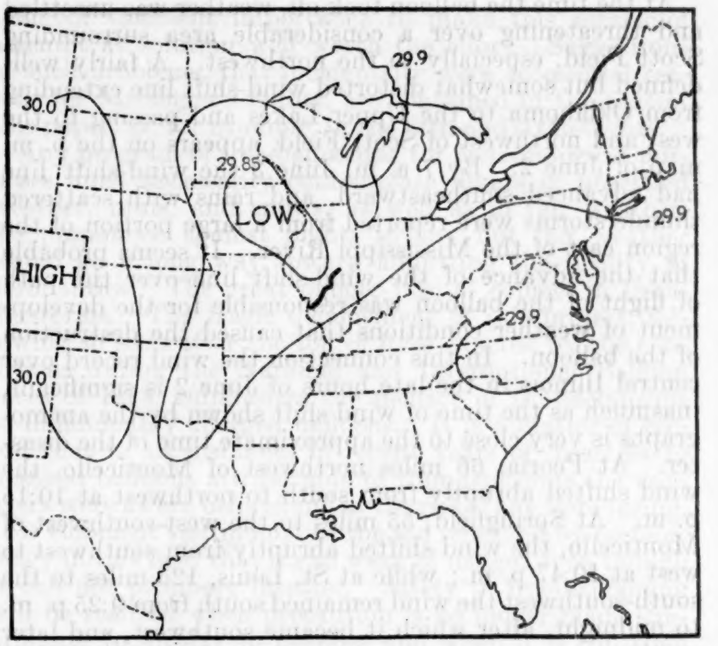

FIG. 9.—Pressure distribution at sea level, 8 p. m., 75th meridian time, June 2, 1924. Balloon path in heavy line

alternate ascents and descents were probably deliberately made with a purpose in mind. A clue to what this purpose might have been is given in the following extract from the writings of Doctor Meisinger, already referred to:

> Flights at varying elevations: * * * to begin a flight in the southerly current in front of a cyclone, proceed northward in it until one is above the easterly surface wind, and allow the balloon alternately to ascend and descend through the cloud layer from one stream to the other. By coming below the cloud layer for, say, a half hour, one could pick up his location, then ascend through the cloud and remain above it for another half hour, after which another descent could be made, position obtained, indefinitely so long as the ballast and gas permitted. This would give the direction of both streams.

Opposed to this idea of purposeful manipulation of the altitude of the balloon, is the fact that no altitude was maintained long enough to determine the direction of stream flow. It is therefore possible after all that the peculiar record of altitude was due to difficulty in controlling the balloon, as was inferred to be the case in the previous two flights. Intimation of such difficulty of control is conveyed by the frequent entries of ballast released while the balloon was descending, of which an instance is shown in the excerpted last four lines of the log given below.

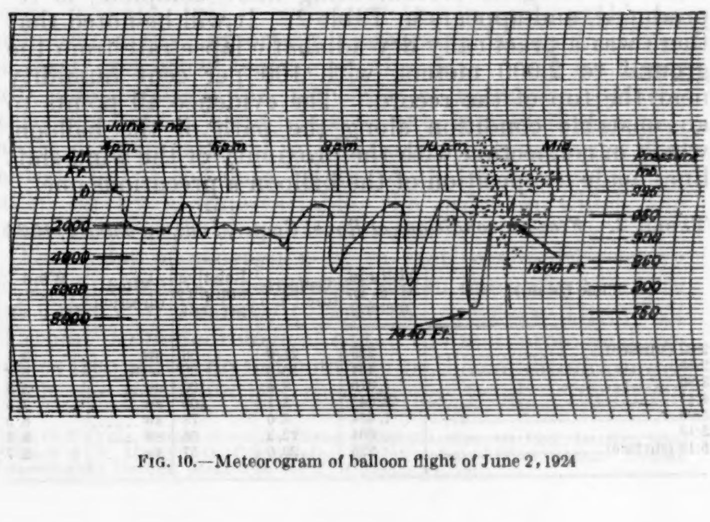

FIG. 10.—Meteorogram of balloon flight of June 2, 1924

At the time the balloon took off, weather was unsettled and threatening over a considerable area surrounding Scott Field, especially to the northwest. A fairly well-defined but somewhat distorted wind-shift line extending from Oklahoma to the Upper Lakes and passing to the west and northwest of Scott Field, appears on the p. m. map of June 2. By 7 a. m. June 3 the wind-shift line had advanced southeastward, and rains with scattered thunderstorms were reported from a large portion of the region east of the Mississippi River. It seems probable that the advance of the wind-shift line over the path of flight of the balloon was responsible for the development of weather conditions that caused the destruction of the balloon. In this connection the wind record over central Illinois in the late hours of June 2 is significant, inasmuch as the time of wind shift shown by the anemographs is very close to the approximate time of the disaster. At Peoria, 66 miles northwest of Monticello, the wind shifted abruptly from south to northwest at 10:15 p. m. At Springfield, 55 miles to the west-southwest of Monticello, the wind shifted abruptly from southwest to west at 10:47 p. m.; while at St. Louis, 125 miles to the south-southwest the wind remained south from 9:25 p. m. to midnight, after which it became southwest, and later northwest.

Conditions probably did not appear dangerous to the pilots until after the last entry in the log, which was made at 10:48 p. m., when the balloon had reached the highest point of any ascent, and just before it began the rapid descent that was soon to be followed by the death of both pilots. The first mention in the log of the balloon being in clouds appeared at 9:40 p. m., which probably marks the beginning of development of threatening weather in the vicinity of the balloon. The following is a copy of the entries in the last four lines of the log:

Time (p. m.)	Altitude (feet)	Ballast (bags)	Temperature (°F.)	Remarks
9:40	5,900	1	----------	Over Macon. In cloud. WOAW.
9:50	3,000	1	----------	5 mi. S. Decatur.
10:18	1,400	1	----------	KSD weather bulletin rec'd.
10:48	[1] 7,000	1	36	Taking altitude to try to go eastward and avoid LOW.

[1] 7,440 corrected.

The conditions surrounding the line of flight favored the formation of instability showers and thunderstorms. This is indicated both by the temperature record of the balloon and the aerological observations at Royal Center, Ind., about 200 miles away. As the balloon record of temperature agrees quite well with that observed at Royal Center a few hours earlier, the Royal Center aerological record, being more complete, is reproduced, and appears in Table 2. It will be noted that there was a practically dry adiabatic lapse rate from the ground to 2,000 meters, with 100 per cent humidity near the top of the record. The evidence all points to an unstable condition along the path of the balloon, which in connection with the proximity of the wind-shift line, made the position of the balloon a precarious one.

TABLE 2.—*Free-air conditions at Royal Center, Ind., on June 2, 1924*

Time (p. m.)	Altitude, M. S. L. (meters)	Temperature (°C)	Relative humidity (per cent)	Wind direction	Wind velocity (m. p. s.)
2:09 (surface)	225	21.0	56	sw	3.1
2:15	494	18.0	58	wsw	6.2
3:36	1,370	8.4	100	sw	5.8
4:41	2,045	3.1	100	sw	7.5
5:00	1,464	5.0	73	sw	6.5
5:12	664	12.2	56	sw	8.5
5:19 (surface)	225	20.0	57	sw	2.7

The meteorogram shows a rapid drop taking 12 minutes from the last high point reached at 7,440 feet down to an altitude of 1,700 feet. Below this point the record is blurred, but descent for the remainder of the distance to the ground was probably at the same or even greater rate of speed. After a short interval, corresponding to about 12 minutes on the meteorogram, but undoubtedly due in part at least to jarring of tle instrument caused by landing of the basket, the record shows a rapid rise from the ground to 1,500 feet, followed immediately by an equally or more rapid fall. The total duration of this last ascent and descent was about six or seven minutes.

The descent from 7,440 feet, at about 10:50 p. m., while much more rapid than any of the previous descents, was still apparently too slow to indicate that any accident had befallen the pilots. It is probable that on account of suddenly developing threatening weather, a quick descent was decided upon, and that the last part of the descent was so hastened by valving that a bumpy landing was made. Ascent was again begun, evidently by intention, and when an altitude of 1,500 feet was reached the balloon became ignited, causing its destruction with tragic consequences.

The cause of ignition of the balloon was undoubtedly either a direct stroke of lightning, or a spark, probably from the radio antenna, occurring simultaneously with a discharge of lightning. An example of the severity of the charge possible on the radio antenna during threatening weather is given in the following extract from a letter by Doctor Meisinger referring to the last portion of the flight of April 23–24, when flying close to thunderstorms:

> The bulletin the next day (April 24) at 11 a. m., was not listened to, owing to heavy static which not only prevented our hearing more than WOC's time signals but also caused such violent sparking about the radio set as to cause us to reel in the trailing antenna and attach it to the counterpoise, which operation was not accomplished without the reception of violent shocks by Lieutenant Neely.

Another possible source of danger in free ballooning during thunderstorms is mentioned by Mr. Ralph Upson, the noted aeronaut. From the July 1, 1924 number of the National Aeronautic Association Review, the following paragraph from an article by Mr. Upson is quoted:

> During the past few months it has been brought out by authorities on electrostatics that a discharge of gas or ballast from a free balloon in flight seems to break down the dielectric of the air, and provide a path for a charge to pass from cloud to cloud, or to a lesser extent from cloud to ground.

From the testimony of persons living in the vicinity of the place where the disaster occurred, it has been ascertained that the balloon caught fire simultaneously with or soon after the occurrence of a crash of lightning. It is therefore very probable that the balloon was struck directly by a stroke of lightning. Other evidence, such as condition and position of the wreckage and bodies of the pilots, leads strongly to the belief that Doctor Meisinger was instantly killed when the balloon was ignited, and that Lieutenant Neely met his death in the attempt to save himself by parachuting.

CONCLUSIONS

1. The flights of this series add to the testimony of ordinary aerological observations to the effect that free-air pressure maps according to the Meisinger system can always be relied on as being at least approximately correct. The qualification implied by saying "approximately" refers to the crudities inherent in a system based, as it is, on the comparatively meager records of aero-

logical observations available. Now that the long-sought foundation for a reliable system of pressure reduction is laid out, further developments in aerological work and the establishment of truer free-air normals, hold out hopes of future refinements in the system to the point of unreserved acceptance of the results.

2. As brought out in the text of this paper, there are a number of difficulties in the way of representing free-air trajectories by means of the free balloon, or of accepting such representation as valid. The chief of these are the difficulties, in practice, of maintaining constant altitude and determining the location of the balloon, and considerations of vertical component of air movement. The question as to whether further practice of free ballooning might lead to closer approximation to the facts on this particular point, vies with the question as to whether the additional knowledge gained would justify the effort and expense involved.

3. Referring to the general problem of free-ballooning with relation to meteorology, there can be no question as to the reciprocal benefits of one to the other; in fact, the very dependence of ballooning on meteorology compels the belief that meteorology can not help but add to its fund of knowledge from a pursuit to which it is indispensable. There are a number of problems in meteorology peculiarly adaptable to free balloon investigation, some of sufficient importance to make this means of attempt at solution well worth the effort. Suggestions of such problems, that incidentally were accessorial reasons for Meisinger's flights, are contained in the text of this paper, as, for example, in the fifth and sixth flights.

Any program of free-ballooning for meteorological purposes must necessarily contemplate flights in unsettled weather, rains, and snows, as well as in fair weather. To pronounce against flights in any but fair weather would go a long way toward admitting the futility of aeronautics. The great danger lies, of course, in thunderstorms. The tragic denouement of this project, following so soon after the toll of lives exacted by the conditions during the National and International Balloon races of 1923, emphasizes the menace of thunderstorms to inflammably charged balloons. It is a matter of record that in all instances in recent years of disasters to manned balloons attributable to thunderstorms the voyagers were aware beforehand of the risks they were facing. It is sufficient testimonial to the aid rendered by meteorology in this field that it can warn of danger even though it can not prophesy disaster. Safety in free-ballooning will be realized when precaution is no longer made subordinate to loyalty to purpose and when it is conceded that "safety first" is as applicable and justifiable in this line of scientific work as in any other peacetime endeavor.

ON THE MEAN VARIABILITY IN RANDOM SERIES[1]

By EDGAR W. WOOLARD

[U. S. Weather Bureau, Washington, D. C., March 27, 1925]

The human mind is so constituted that, when confronted by an extensive array of numerical data, it is incapable of adequately grasping the significance of the figures or of detecting and comprehending the relations and laws exhibited by the data. To overcome this defect, special methods, known as statistical, have been devised for the scientific treatment of collections of data pertaining to mass phenomena. Statistics accomplishes its object by displaying data in forms such that their significance can be more readily grasped, and by inventing special analytical processes designed to reveal the laws and relations concealed in the figures.

One common statistical procedure for rendering data amenable to our mental faculties is that of replacing the original large body of raw numerical material by a very small and compact set of summary coefficients which concisely, yet adequately and comprehensively, resume in themselves all the essential features of the complete data. Of course such a replacement is necessarily made at the expense of detail—no summary can, by virtue of its very nature, contain *all* the facts—but the effort is made to retain in the summary all the facts and features *essential or relevant to the purposes in hand.*

An extensive body of numerical data may thus be succinctly described or characterized by, and, at least for many purposes of statistical analysis, may be replaced by, a brief set of statistical coefficients or indices, one coefficient for each of the important and relevant features of the data. The comparative analysis of two different sets of data, and of the respective phenomena to which they pertain, in respect to each of their essential characteristics, then becomes largely a matter of the comparison of corresponding statistical indices; two different phenomena may be identical in that aspect characterized by the arithmetic mean of the data, and yet differ widely in respect to the feature characterized by, say, the standard deviation. Obviously, in any given case it is a matter of very great importance to be sure we have included in the set of coefficients an index for each and every important aspect of the phenomena under consideration.

Now, the statistical coefficients pertaining to a single variable to which nearly all the attention of statisticians has thus far been directed relate entirely to the various characteristics of the frequency distribution.[1] In most cases, perhaps, this is sufficient, but in some problems, including many important meteorological applications, at least one other feature of the data must be taken into consideration, viz, the *order of succession.* If the statistical data in hand relate to, say, biometric measurements, it is immaterial in what order the data are presented; but if the data relate to the successive values taken on by a time-variable, the order in which the values occur may be quite relevant.

The order of succession is, in fact, one of the many peculiar problems encountered[2] when one seeks to apply the Theory of Probability and the ordinary Theory of "Errors" to meteorological data; the meteorological variables frequently do not conform to the conditions under which the mathematical theories are valid. Statistical

[1] In view of the usefulness of the so-called Goutereau ratio in meteorological investigations, Mr. Woolard was asked to examine the question as to whether there could not be developed a generalization of Goutereau's theorem, which as we understand it applies strictly to numbers in a Gaussian distribution. From a very superficial examination on my own part, I am impressed with the fact that this ratio, while not constantly equal to the square root of 2, (1.41), nevertheless has a value differing but little from that value for very widely differing frequency distributions. For example, the U-shaped distribution of a table of sines seems to lead to a ratio of about 1.25.

The problem might be stated as follows:

Given a limited series of numbers, a, b, c, . . . k, of which f_a, f_b . . . f_k represent the relative frequencies of these numbers. Regardless of the order of succession, the mean deviation of these numbers may be expressed as *md*. If the average value of the mean variation of the numbers in a sequence of unrelated numbers is v, what is the ratio of v÷*md*?—*C. F. Marvin.*

[1] See G. U. Yule, *Introduction to the Theory of Statistics*, chap. vii. 7 ed., London, 1924.

[2] See, e. g., V. H. Ryd, On Computation of Meteorological Observations. Danske Meteorologiske Institut, *Meddelelser Nr. 8.* Copenhagen, 1917.

meteorology thus furnishes examples wherein it is highly desirable to have some index depending upon, and completely characterizing, the order of succession of the values in a statistical series.

Suppose, for example, that we have an observed sequence of values of a time-variable, say a series of daily mean temperatures for a number of consecutive days,

$$t_1\, t_2\, t_3 \cdots\cdots\cdots t_k \cdots\cdots \qquad (1)$$

If the numbers t_k were written on balls, and the balls drawn one at a time at random from an urn, the resulting sequence of values might, in some important respects, differ widely from the observed sequence (1)—e. g., in the case of daily temperatures, long series of successively increasing or decreasing values would be less frequent in the series obtained by the chance drawings than in the sequence produced by nature—yet the frequency distributions of the two, and the values of all the statistical constants pertaining thereto, would be identical. In one case we have a sequence brought about by the operation of pure chance only, whereas in the other case consecutive values may not be completely independent of one another; yet none of the tests ordinarily applied[3] to determine, when it is essential to know, whether or not the values of a variable are due to fortuitous causes, would distinguish between the two cases, because these tests relate only to the frequency distributions.

Very little work has been done on this matter. Here, as in the case of so many other statistical questions, the problem was first encountered as a special case in the theory of errors of precision measurements, viz, in connection with testing observations for the presence of systematic errors.[4]

The first investigation of the general statistical problem seems to have been that of Grossmann;[5] recently, however, some errors in Grossmann's reasoning have been pointed out by Besson, who has corrected and extended[6] the work; but nothing in the nature of a statistical coefficient has been provided by any of these investigations.

A statistical index characterizing the order of succession was first devised by Goutereau, in 1906.[7] He defined a *variability* as the absolute value of the difference between any number in a sequence and the next consecutive number; and with the aid of Maillet he showed that, provided the frequency distribution were Gaussian, the ratio of the mean of the variabilities to the mean deviation must be equal to $\sqrt{2}$ if the deviations from the mean were legitimately to be likened to fortuitous errors. The ratio is actually but about half this value in general in the case of daily temperatures.

The Goutereau Ratio, as it may be called, was applied by its author only to normal frequency distributions. Moreover, it seems to the writer that the derivations of the formulae, as given by Goutereau, are not as clear and satisfactory as they might be made, and furthermore the equations as printed contain several serious errors. Therefore it seems worth while to remedy these defects in Goutereau's presentation, and, if possible, to extend the work to include distributions that are not normal.

Let a time-variable t, a sequence (1) of n of whose values we have observed, have the following frequency distribution:

$$\begin{array}{ll} \textit{Values:} & x_1\, x_2\, x_3 \cdots\cdots x_i \cdots\cdots x_s \\ \textit{Frequencies:} & a_1\, a_2\, a_3 \cdots\cdots a_i \cdots\cdots a_s \end{array} \qquad (2)$$

$$\sum_i a_i = n \qquad (3)$$

If the variable t be a continuous one, (2) gives the ordinary histogram, the x_i being the mid-points of the classes.

The Arithmetic Mean of t is

$$M = \frac{\sum_k t_k}{n}, \qquad (4)$$

while the standard deviation and the mean deviation are, respectively,

$$\sigma = \sqrt{\left\{\frac{\sum_k (t_k - M)^2}{n}\right\}}; \qquad (5)$$

$$\theta = \frac{\sum_k \left| t_k - M \right|}{n}. \qquad (6)$$

The mean, the standard deviation, and the mean deviation are indices which characterize certain features of the frequency distribution (2), and they would have the same values in whatever order the t_k were observed to occur. In the variabilities and their mean, however, we have something depending upon the order in which the t_k present themselves in the sequence. The variabilities in a sequence such as (1) are given by

$$v_k = \left| t_{k+1} - t_k \right|, \qquad (7)$$

and the mean variability in a series of N values is

$$V_m = \frac{\sum_{k=1}^{N-1} v_k}{N-1}. \qquad (8)$$

Now, if we assume that the observed sequence (1) is a representative sample of the results that will follow the operation of the causes producing the phenomenon under observation, then the frequency ratios a_i/n may be taken to be the *a posteriori* empirical probabilities of the individual values x_i, and these may in turn be identified with the postulational *a priori* mathematical probabilities of the x_i. The production of the observed series through the operation of the complex of causes determining the phenomenon may then be simulated by drawing balls from an urn in which either (A) there is an infinite number of balls marked with the x_i in such proportions that for any n balls there are on the average a_1 marked x_1, a_2 marked x_2, and so on, the proportions of the different kinds remaining the same no matter how many may be drawn out; or (B) in which there are n balls marked with the various x_i in the proper proportions, the balls being returned after each drawing before the next drawing is made. (This assumes, of course, that we are dealing with a Bernoullian Series).

If we make a number, N, of successive drawings from the urn, we obtain a so-called random or chance sequence

[3] Goutereau, *Annuaire de la Soc. Mét. de France*, 54, 122–123, 1906; Woolard, MO. WEATHER REV., 49, 132–133, 1921.

[4] E. Abbe, Ueber die Gesetzmässigkeit in der Verteilung der Fehler bei Beobachtungsreihen, Jena, 1863 (*Habilitationsschrift*); *Ges. Abh.*, Bd. II, Jena, 1906, pp. 55–81. "Abbe's Criterion" has been modified slightly by Helmert; see F. R. Helmert, *Die Ausgleichungsrechnung nach der Methode der Kleinsten Quadrate*, 2te Aufl., Leipzig, 1907, pp. 341-345. Another method of dealing with the same question was used by F. R. Helmert and W. Seibt, Das Mittelwasser der Ostsee bei Swinëmunde. 2 Mitt. *Veröff. d. Kön. Preuss. Geod. Inst.*, 1890; *cf. Jahresbericht d. Direktors*, 1889–90, p. 26–27.

[5] L. Grossmann. Die Aenderung der Temperature von Tag zu Tag an der deutschen Kuste. *Aus dem Archiv der Deutschen Seewarte*, XXIII Jahrgang, 1900, pp. 34–37.

[6] L. Besson. On the Comparison of Meteorological Data with results of Chance. Translated by Edgar W. Woolard. MO. WEATHER REV, 48, 89–94, 1920.

[7] Ch. Goutereau. Sur la variabilité de la température. *Annuaire de la Soc. Mét. de France*, 54, 122-127, 1906; Edgar W. Woolard, The Mean Variability as a Statistical Coefficient, MO. WEATHER REV., 49, 132–133, 1921.

of numbers; and it is possible under such circumstances, as we shall show, to compute the mathematical expectation[8] of the value of a variability. A comparison of this theoretical or "expected" value with the actual mean of the observed variabilities may show whether or not the observed sequence constitutes a chance sequence, i. e., whether the order of succession in Nature is a random one, controlled by pure chance alone, or is controlled by some *systematic* influence.

An individual variability in any sequence made up from the frequency distribution (2) may happen to have any one of the various possible values of

$$|x_i - x_j|, \; i, j = 1, 2, 3, \ldots\ldots s. \tag{9}$$

Obviously, the total number of values which the expression (9) may take on is given by the number of "combinations with repetitions" or "complete combinations" of s things two at a time, which is[9]

$$\frac{(s+1)!}{(s-1)!\,2!} = \frac{s\,(s+1)}{2}; \tag{10}$$

but by no means all these values are numerically distinct. The same value zero, e. g., which occurs whenever $i=j$, is produced by s of these combinations, and in general the remaining

$$\frac{s\,(s+1)}{2} - s = \binom{s}{2} \tag{11}$$

combinations will not all produce different numerical values.

Now, the total number of possible ways in which variabilities may be produced is given by the number of "permutations with repetitions" or "complete arrangements"[9] of n things two at a time, which is

$$n^2 \tag{12}$$

each of which is an "equally probable event." By equation (3)

$$\begin{aligned} n^2 = a^2_1 + a_2^2 + &\ldots\ldots\ldots\ldots\ldots + a^2_s \\ &+ 2a_1a_2 + 2a_1a_3 + 2a_1a_4 + \ldots\ldots\ldots + 2a_1a_s \\ &+ 2a_2a_3 + 2a_2a_4 + \ldots\ldots\ldots + 2a_2a_s \\ &+ \ldots\ldots\ldots\ldots\ldots + 2a_{s-1}a_s \\ &= \sum_{i=1}^{s} a^2_i + 2\sum_{m=1}^{s-1}\sum_{i=1}^{s-m} a_i a_{i+m}. \end{aligned} \tag{13}$$

It is easily seen that the $\sum a^2$ ways comprise those of the n^2 permutations which give a zero value to (9), while the term $2a_qa_r$ corresponds to the permutations which make (9) equal to $|x_q - x_r|$.

Hence the probability of a zero variability in a sequence drawn at random from the distribution (2) is

$$\frac{\sum_i a^2_i}{n^2}, \tag{14}$$

while the probability of a variability $|x_q - x_r|$ is

$$\frac{2a_qa_r}{n^2}. \tag{15}$$

The probabilities (14) and (15) may also be found by noting that the respective probabilities of the x_i in a single drawing are

$$p_1 = \frac{a_1}{n},\; p_2 = \frac{a_2}{n},\; \ldots\ldots,\; p_i = \frac{a_i}{n},\; \ldots\ldots,\; p_s = \frac{a_s}{n}; \tag{16}$$

so that the probability of x_r coming adjacent to x_q in a random series is

$$\frac{a_q}{n}\cdot\frac{a_r}{n} + \frac{a_r}{n}\cdot\frac{a_q}{n} = \frac{2a_qa_r}{n^2}, \tag{17}$$

whereas the probability of two identical values x_q being adjacent is merely

$$\frac{a_q}{n}\cdot\frac{a_q}{n} = \left(\frac{a_q}{n}\right)^2 \tag{18}$$

If the x_i are the midpoints of the classes into which the t_k are grouped in forming the frequency distribution (2), and h the (constant) class interval, then we may always write

$$x_i = c + ih, \quad i = 1, 2, \ldots\ldots s, \tag{19}$$

where c is some constant, positive, negative, or zero. The same is true if the x_i are actual values of a discrete variable, h being the unit of measurement. Then the *numerically distinct* values of the expression (9), any one of which an individual variability may happen to have, are

$$0,\; h,\; 2h,\; 3h,\; \ldots\ldots\ldots,\; (s\text{-}1)h. \tag{20}$$

Of the $s(s+1)/2$ complete combinations to each of which corresponds a value of (9), $(s-m)$ produce the *same* numerical value, viz, mh.[10]

If we have

$$|x_q - x_r| = |(q-r)\,h| = mh, \tag{21}$$

then we must have

$$q - r| = |m; \tag{22}$$

and the $(s-m)$ combinations all of which result in the same value mh for (9) are

$$|x_{i+m} - x_i|,\; i = 1, 2, 3, \ldots\ldots, (s-m), \tag{23}$$

the respective probabilities of which are, by (15),

$$\frac{2}{n^2}\, a_i a_{i+m},\; \begin{cases} m \neq 0 \\ i = 1, 2, 3, \ldots, (s-m) \end{cases} \tag{24}$$

(It is not necessary to take into account the cases in which $m=0$, since they would not contribute anything to our final result).

Therefore, the mathematical expectation of the variability—the expected, probable, or mean, variability in an unlimited sequence of random drawings—is given by the equation

$$\mathrm{E}(v_k) = \sum_{m=1}^{s-1} mh \sum_{i=1}^{s-m} \frac{2}{n^2}\, a_i a_{i+m} = \frac{2h}{n^2}\left\{\sum_{m=1}^{s-1} m\left[\sum_{i=1}^{s-m} a_i a_{i+m}\right]\right\} \tag{25}$$

[8] A good exposition of the nature and significance of mathematical expectation will be found in G. Castelnuovo, *Calcolo delle Probabilità*, Milan, 1919, capit. iii; see also Arne Fisher, *Mathematical Theory of Probabilities*, Vol. 1, 2 ed., pp. 102–103, New York, 1922.

[9] For the combinatorial formulae needed in this paper, see E. Netto and H. Vogt, Analyse Combinatoire et Théorie des Déterminants, *Encyc. des Sci. Math.*, Tome I, vol. 1, Fasc. 1, Paris, 1904; or E. Netto, *Lehrbuch der Combinatorik*, Leipzig, 1901.

[10] Since $\sum_{m=0}^{s-1}(s-m)$ is an arithmetic progression (the sum of the first s natural numbers in fact), its sum is, as it should be, $\frac{s\,(s+1)}{2}$, the total number (10) of combinations.

A check on the accuracy of formula (25) is afforded by the following somewhat different derivation: The value x_i, with probability a_i/n, having been drawn, the variability mh will result if the next value drawn be

$$x_i \pm mh = c + (i \pm m)\,h; \tag{26}$$

the probability of such an event is of course

$$\frac{a_i}{n}\cdot\frac{a_{i\pm m}}{n}. \tag{27}$$

Now, in order that (26), the second value drawn, may possibly differ from the first, x_i, by as much as $\pm mh$, it is necessary and sufficient that i have any one of the values

$$i = \begin{cases} 1,\ 2,\ 3, \dots\dots, (s-m), \\ m+1,\ m+2 \dots\dots, s. \end{cases} \tag{28}$$

Hence, by the addition theorem in the Calculus of Probabilities, the probability of the variability mh, $m=1, 2, 3, \dots\dots, (s-1)$, is [11]

$$\frac{1}{n^2}\left[\sum_{i=1}^{s-m} a_i a_{i+m} + \sum_{i=m+1}^{s} a_i a_{i-m}\right]; \tag{29}$$

and the mathematical expectation becomes

$$\mathrm{E}\,(v_k) = \frac{1}{n^2}\sum_{m=1}^{s-1} mh\left[\sum_{i=1}^{s-m} a_i a_{i+m} + \sum_{i=m+1}^{s} a_i a_{i-m}\right]$$
$$= \frac{2h}{n^2}\left\{\sum_{m=1}^{s-1} m\left[\sum_{i=1}^{s-m} a_i a_{i+m}\right]\right\},$$

the same as (25). This formula lends itself very readily to numerical computation, as the examples to be given below will show.

If the x_i are all equally probably, $a_i = const. = a$, $n = sa$, and (25) reduces to

$$\mathrm{E}\,(v_k) = \frac{2h}{s^2}\sum_{m=1}^{s-1} m\,(s-m) = \frac{h\,(s-1)\,(s+1)}{3s}. \tag{30}$$

By equations (6) and (25), the expected value of the Goutereau Ratio in a random sequence

$$t_1\, t_2\, t_3 \dots\dots\dots t_k \dots\dots\dots t_N \tag{31}$$

of N values drawn from the frequency distribution (2) is

$$\mathrm{G_e} = \frac{\mathrm{E}\,(v_k)}{\theta} = \frac{2h}{n}\left\{\frac{\sum_{m=1}^{s-1} m\left[\sum_{i=1}^{s-m} a_i a_{i+m}\right]}{\sum_{i=1}^{s} a_i\,|\,x_i - \mathrm{M}\,|}\right\}. \tag{32}$$

The actual value will be

$$\mathrm{G_o} = \frac{\frac{1}{\mathrm{N}-1}\left[\sum_{k=1}^{N-1}\left|t_{k+1} - t_k\right|\right]}{\sum_{k=1}^{N}\left|t_k - \frac{\sum t_k}{\mathrm{N}}\right|}. \tag{33}$$

Now, if random drawings are made from an urn which contains the distribution (2), then, just as each of the *individual* variabilities in the sequence obtained may have *any* one of the values (20), so if a *number* of sequences like (31) are drawn, the actual mean variabilities of these different sequences will range over a number of different values, none of which may happen to coincide with each other or with the expected value; so, too, the mean deviations of the individual sequences will depart from each other and from the value (6). In other words, the actual mean variabilities, mean deviations, and Goutereau ratios of different individual sequences drawn perfectly at random from the same unvarying universe will, like all statistical coefficients, be subject to fluctuations of sampling, of magnitudes dependent on the size of the sample; and in any specific case, before any conclusions as to the presence or absence of systematic control can be drawn from a comparison of the two values given by (32) and (33), it is necessary to know whether or not the difference, if any, can be ascribed to errors of sampling.

From the known formula for the standard error of the mean of an unbiased sample, and the theorem that the standard deviation of the difference of two uncorrelated quantities is equal to the square root of the sum of the squares of the standard deviations of the quantities,[12] we see that the *standard error* of the *observed* mean variability in a *random* series is

$$\epsilon = \frac{\sigma\sqrt{2}}{\sqrt{\mathrm{N}-1}}, \tag{34}$$

where σ is the standard deviation of (2). (The standard error of a mean, it will be recalled, is independent of the form of the frequency distribution).

However, the usual difficulties are of course encountered when we come to apply our formulæ to actual cases: When drawing sample sequences (31) from an urn of known composition (2), we know *a priori* the true values of the probabilities (16) and of σ, θ, etc.; but any sequence actually presented to us by Nature is a sample drawn from a universe of unknown composition, and in general the best we can do is to adopt for these quantities the values given by this sample itself. All these adopted values are then subject to errors of sampling,[13] and in the case of small samples are quite unreliable; nor are we sure in general that the true values remain constant. Therefore, in actual practice, the value which we compute from (32) is itself in error because of our ignorance of the true composition of the universe from which the observed sequence was drawn; and, furthermore, if we do not know whether or not the observed sequence is a random one, we can not tell whether or not (34) would be applicable even if the real value of σ were known.

Now, suppose that we have for the frequency distribution not a histogram (2) but an analytical expression, i. e., the equation to the frequency curve, so that

$$\left.\begin{aligned} a &= n\varphi\,(x) \\ p &= \ \varphi\,(x) \end{aligned}\right\},\ \mathrm{L_1} \leq x \leq \mathrm{L_2}. \tag{35}$$

Then, following the second method by which we deduced equation (25), we have for the probability of a variability of magnitude h

$$\int_{\mathrm{L_1}}^{\mathrm{L_2}-h}\varphi\,(x)\,\varphi\,(x+h)\,dx + \int_{\mathrm{L_1}+h}^{\mathrm{L_2}}\varphi\,(x)\,\varphi\,(x-h)\,dx,\ 0 \leq h \leq |\mathrm{L_2}-\mathrm{L_1}|; \tag{36}$$

and for the expected variability

$$\mathrm{E}\,(v) = \int_0^{|\mathrm{L_2}-\mathrm{L_1}|} h\left[\int_{\mathrm{L_1}}^{\mathrm{L_2}-h}\varphi\,(x)\,\varphi\,(x+h)\,dx + \int_{\mathrm{L_1}+h}^{\mathrm{L_2}}\varphi\,(x)\,\varphi\,(x-h)\,dx\right]dh. \tag{37}$$

Thus, if the distribution be normal, and $x=0$ is the mean, then

$$a = \frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{x^2}{2\sigma^2}\right), -\infty \leq x \leq +\infty; \tag{38}$$

[11] The case $m=0$ has again been excluded; including it, the sum of the probabilities (29) is seen, by equation (13), to be unity, as of course it must.

[12] G. U. Yule, *Introduction to the Theory of Statistics*, 5 ed., pp. 344 *ffg.*, and 210-211; London, 1919. British M. O., *Computer's Handbook*, Sec. V, subsec. 2, chap. v; London, 1915.

[13] See *Handbook of Mathematical Statistics*, ed. by Rietz, chap. v, especially pp. 77, 78. Boston, 1924.

and

$$\mathrm{E}\,(v)=\int_0^\infty h\left\{\frac{1}{2\pi\sigma^2}\int_{-\infty}^{+\infty}\exp\left(-\frac{x^2}{2\sigma^2}\right)\left[\exp\frac{-(x+h)^2}{2\sigma^2}+\exp\frac{-(x-h)^2}{2\sigma^2}\right]dx\right\}dh$$

$$=\frac{1}{2\pi\sigma^2}\int_0^\infty h dh\int_{-\infty}^{+\infty}\left\{\exp\frac{-[x^2+(x+h)^2]}{2\sigma^2}+\exp\frac{-[x^2+(x-h)^2]}{2\sigma^2}\right\}dx. \tag{39}$$

The integrations may be carried out by means of the substitutions

$$\begin{aligned} x+(x\pm h)&=2x\pm h=z,\\ x&=\tfrac{1}{2}(z\mp h),\\ x^2+(x\pm h)^2&=\tfrac{1}{2}(z^2+h^2)\\ dx&=dz/2; \end{aligned} \tag{40}$$

whence

$$\mathrm{E}\,(v)=\frac{1}{2\pi\sigma^2}\int_0^\infty h dh\int_{-\infty}^{+\infty}\exp\frac{-(z^2+h^2)}{4\sigma^2}\,dz$$

$$=\frac{1}{\sigma\sqrt{\pi}}\int_0^\infty h\exp\left(-\frac{h^2}{4\sigma^2}\right)dh=\frac{2\sigma}{\sqrt{\pi}}. \tag{41}$$

The mean deviation in a normal distribution is given by [14]

$$\theta=\frac{\sqrt{2}}{\sigma\sqrt{\pi}}\int_0^\infty x\exp\left(-\frac{x^2}{2\sigma^2}\right)dx=\sigma\sqrt{\frac{2}{\pi}}. \tag{42}$$

Hence, in a random sequence drawn from a normal distribution, the value of the Goutereau Ratio becomes

$$\mathrm{G_N}=\frac{2\sigma}{\sqrt{\pi}}\cdot\frac{\sqrt{\pi}}{\sigma\sqrt{2}}=\sqrt{2}, \tag{43}$$

the result of Goutereau and Maillet.[15]

Table 1

x	Urn composition		Composition, sample of 1,001		$p'-p$
	a	p	p'	Stand. error	
1	5	.082	.089	.009	+.007
2	4	.065	.057	.007	−.008
3	8	.131	.123	.010	−.008
4	13	.213	.226	.013	+.013
5	22	.361	.349	.015	−.012
6	3	.049	.045	.006	−.004
7	2	.033	.047	.007	+.014
8	4	.066	.064	.008	−.002
	61	1.000	1.000	----------	----------
	M=4.311 σ=1.714 ϑ=1.34		M=4.332 σ=1.739		---------- ---------- ----------

Equation (25) was subjected to experimental test in the following way: Sixty-one beans were marked with the numbers 1, 2, ..., 8 in the proportions given in Table I,[16] and put into a dish; 1001 random drawings were then made, the one drawn being returned each time before the next drawing, and the sequence of numbers thus obtained recorded. Table I also shows the observed frequency distribution for this sample sequence

The expected variability may be computed from equation (25) according to the scheme shown in Table II

The frequency distribution is tabulated in the first two columns, following which are s–1 columns numbered 1, 2, ..., s–1; now, beginning with the last frequency, viz, 4, as multiplier, and taking each of the other frequencies in order—2, 3, ... 5—as a multiplicand, fill out the last row of the table—8, 12, 88 ...., 20; then, using the next to the last frequency—2—as multiplier, and each of the frequencies preceding it—3, 22, ..., 5—as multiplicand, fill out the next to the last row—6, 44, ..., 10; and so on. This can be done quite rapidly with a multiplication table or a calculating machine. Then add up each of the numbered columns, multiply the sum by the number of the column, add these products, and multiply this last sum by $2h/n^2$; the result is the required expectation.

Table 2

x	a	1	2	3	4	5	6	7	
1	5								
2	4	20							
3	8	32	40						
4	13	104	52	65					
5	22	286	176	88	110				
6	3	66	39	24	12	15			
7	2	6	44	26	16	8	10		
8	4	8	12	88	52	32	16	20	
-----	61	522	363	291	190	55	26	20	-----
-----	-----	522	726	873	760	275	156	140	3,452

$$n=61;\ s=8;\ h=1.$$

$$\mathrm{E}(v_k)=\frac{2\times 3452}{61^2}=1.855$$

The expected value of the variability for a random sequence drawn from the frequency distribution of Table I is found to be 1.855; if, as is the case in practise, we had not known the true composition of the universe from which the sequence was drawn, but had been forced to use in (25) the observed composition of the sample itself, we should have found 1.885 for the expected variability. The actually observed mean of the 1,000 variabilities was 1.84, with a *standard error*, according to (34) of .0766, and hence a *probable error* of .052.

The observed sequence of 1,000 variabilities was also cut up into 100 samples of 10 each, and the mean of each of these samples computed. According to (34) the standard error of a mean variability computed from 10 values would be .76; the 100 values were not enough to give a smooth frequency distribution, but after grouping them until a smooth distribution was obtained, they gave a mean of 1.862 and a standard deviation of .61.

Table 3 gives the results of 1,001 drawings from another frequency distribution. The results of these experiments fully confirm the theoretical formulae developed in this paper.

Table 3

x	Urn composition		Sample of 1,001	
	a	p	p'	$p'-p$
1	23	.354	.342	−.012
2	13	.200	.212	+.012
3	9	.138	.141	+.003
4	7	.108	.101	−.007
5	4	.062	.064	+.002
6	3	.046	.040	−.006
7	5	.077	.079	+.002
8	0	.000	.000	±.000
9	1	.015	.021	+.006
	65	1.000	1.000	----------
	M=2.86 σ=2.04		n=65; s=9; h=1 E(v_k)=2.164 V_m=2.150: Standard error, .091; probable error, .061	

[14] *Cf.* Arne Fisher, *Mathematical Theory of Probabilities*, vol. I, 2 ed., pp. 122–24, New York, 1922; G. U. Yule, *Introduction to the Theory of Statistics*, 5 ed., p. 304, London, 1919.
[15] Goutereau, *l.c.*
[16] *Cf.* C. F. Marvin, Mo. WEATHER REV., 52, 440-441, 1924.

ENERGY DISTRIBUTION IN THE VISIBLE SPECTRUM OF SUNLIGHT AND SKYLIGHT

By HERBERT H. KIMBALL

[U. S. Weather Bureau, Washington, March 24, 1925]

In the MONTHLY WEATHER REVIEW for October, 1924, **52**:476, Table 2 gives the relative intensity of sunlight, skylight, and the two combined, for different wave lengths in the visible spectrum. The data for sunlight were derived from Abbot's normal solar energy curve outside the earth's atmosphere (Weighted Mean Curve, 1920 and 1922),[1] in connection with atmospheric transmission coefficients for different wave lengths at Washington, D. C. and Mount Wilson, Calif.[2] The data for skylight have been derived from Priest's determinations of the color temperature of skylight,[3] and "Ratios of direct solar radiation received on a horizontal surface to diffuse sky radiation" given in Table 1 of this REVIEW for October, 1924, above quoted.

The present paper is confined to a consideration of sections (a), (b), and (c) of Table 2 of the above paper. It will be remembered that section (a) showed the conditions that prevailed at Washington on May 14, 1907, which was a typical summer day, with some haze in the atmosphere, but practically no clouds. Section (b) gave the conditions in the mean for the year on cloudless days in Washington, and section (c) the conditions that prevailed at Washington on February 15, 1907, which was a typical clear winter day.

The present note is in response to a request that the data designated "Total" in the sections of Table 2 be presented in a form convenient for determining the distribution in the visible spectrum of the energy received on a horizontal surface on typical cloudless days during the summer and fall months. June 21, September 21, and November 21 were decided upon for the dates of these typical days, and they were assumed to be in character similar to May 14, 1907, in Washington, to an average clear day in Washington, and to February 15, 1907, in Washington, respectively. The aim has been to show from the data given in Table 2 the changes in the energy distribution in the short-wave radiation received from hour to hour on a horizontal surface on the three selected dates.

For this purpose Figures 1, 2, and 3 have been prepared, in which the ordinates give relative intensities of radiation on an arbitrary scale. In all three figures a given value signifies the same intensity. The abscissas give the time in hours from apparent noon. The figures attached to each curve indicate the wave length of the radiation to which it applies, expressed in mμ.

To obtain the curves for Figure 1, (June 21 at latitude 41° N.), it was first necessary to construct auxiliary curves by plotting against solar altitudes the "Total" energy for the different wave lengths, as given in section (a) of Table 2,[4] with the sun at different zenith distances, or altitudes. This gave four points of the intensity curve for each wave length. Then from the curves drawn through these points the intensity corresponding to the sun's altitude at latitude 41° N. on June 21 was plotted for each hour from 6 a. m. or 6 p. m. to noon, apparent time.

The sun's altitude at the different hours was obtained by interpolation in Table 1, MONTHLY WEATHER REVIEW, November, 1919, **47**:771.

By a similar process the curves for Figures 2 and 3 were drawn. The process may be extended to any latitude in the eastern part of the United States where the atmospheric conditions do not differ materially from those at Washington.

As is well known, with decrease in the sun's altitude there is an increase in the proportion of the red and yellow rays in direct sunlight with respect to the blue or violet. Figures 1 to 3 show that this is not true with respect to the total daylight (direct sunlight plus diffuse skylight) received on a horizontal surface.

For example, at noon and at 6 p. m. on June 21, with the respective solar altitudes 73.4° and 14.9°, the ratios of the radiation intensity at wave length 397 m μ to that at 556 m μ are 0.57 and 0.82; at noon and 5 p. m. on September 21, with solar altitude 50.7° and 11.9°, they are 0.79 and 1.28; while at noon and 4 p. m. on November 21, with solar altitudes 30.1° and 8.1°, the ratios are 0.84 and 1.73, respectively.

The diurnal variation in the above ratios is due to the fact that while at noon the direct solar radiation received on a horizontal surface may be 6 to 8 times that received diffusely from the sky, which latter may be decidedly blue in color, the proportion is reduced to 1, or even less, as the sun approaches within a few degrees of the horizon.

There is also an annual variation in the blueness of the total daylight for any given altitude of the sun, due to the increased richness in short-wave radiation of both sunlight and skylight in the colder months of the year. The bluer sunlight in the colder months is due to increased atmospheric transmissibility, which is more marked in the short-wave radiation than in the longer waves. The bluer skylight is due to a decrease both in the number and size of the dust particles and water droplets in the atmosphere.

[1] Abbot, C. G. and others. The distribution of energy in the spectra of the sun and stars. Smithsonian Miscellaneous Col., V. 74, No. 7, p. 15 and Figure 1.

[2] Annals of the Astrophysical Observatory, Smithsonian Institution, **3**:135 and 138.

[3] Jour. Opt. Soc. Amer., 1920, **4**: 483; 1923; **7**: 38, 1184.

[4] Loc. cit.

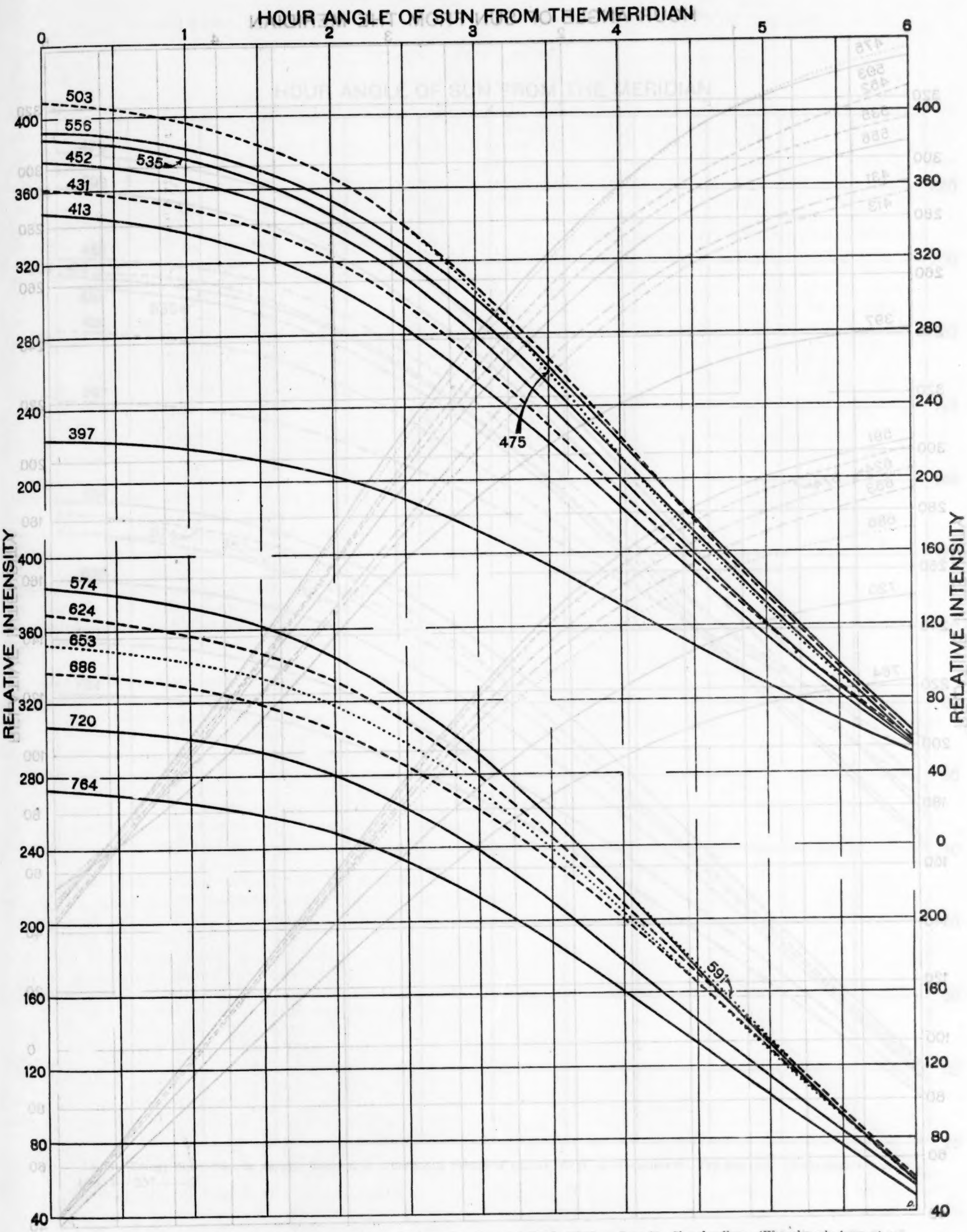

FIG. 1.—Energy distribution in daylight received on a horizontal surface at latitude 41° N. on June 21. Sky cloudless. (Wave lengths in m μ.)

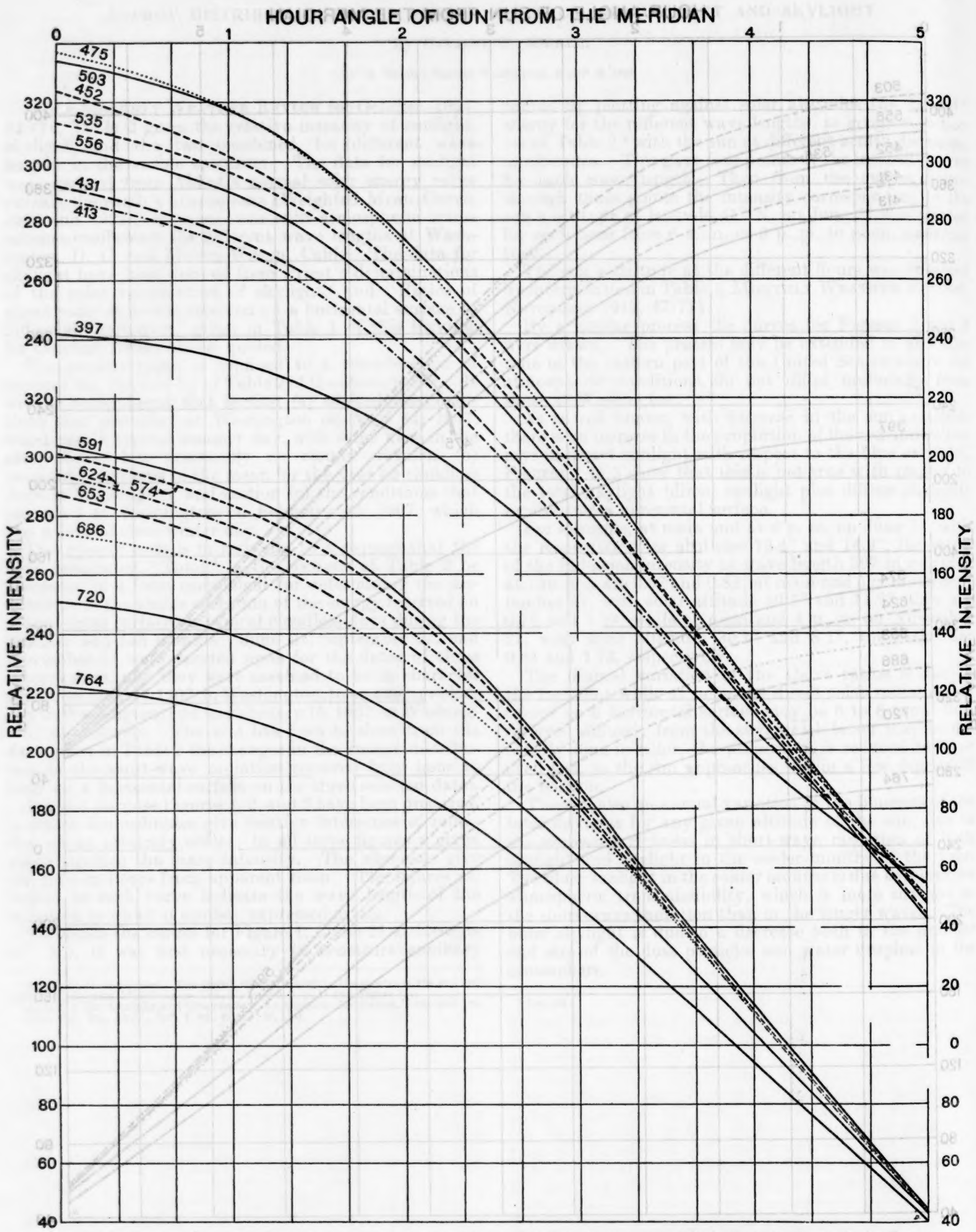

FIG. 2.—Energy distribution in daylight received on a horizontal surface at latitude 41° N., on September 21. Sky cloudless. (Wave lengths in m μ.)

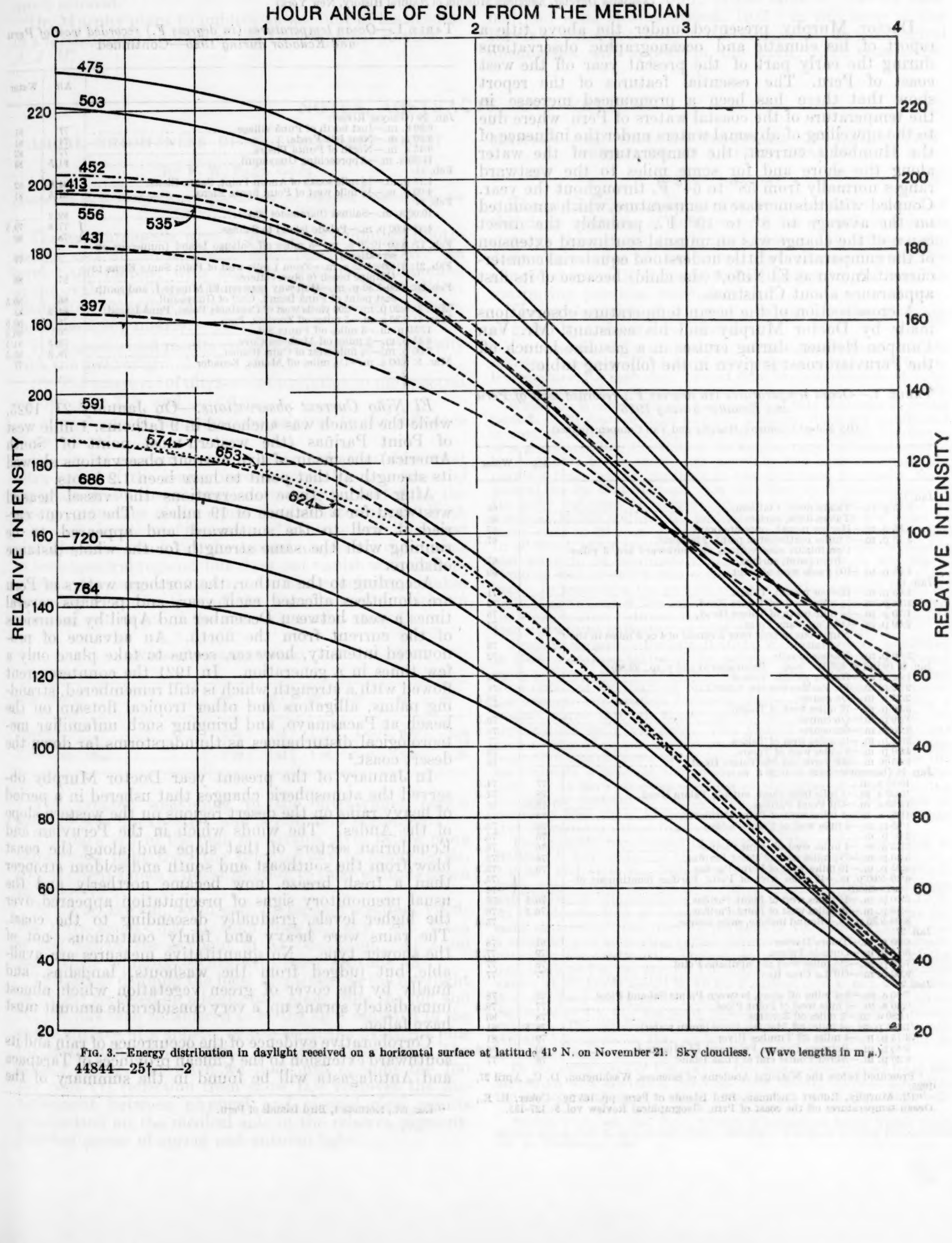

FIG. 3.—Energy distribution in daylight received on a horizontal surface at latitude 41° N. on November 21. Sky cloudless. (Wave lengths in mμ.)

RECENT OCEANIC PHENOMENA ALONG THE COAST OF SOUTH AMERICA[1]

By ROBERT CUSHMAN MURPHY

(Assistant Director, American Museum of Natural History, New York)

Doctor Murphy presented under the above title a report of his climatic and oceanographic observations during the early part of the present year off the west coast of Peru. The essential features of the report show that there has been a pronounced increase in the temperature of the coastal waters of Peru, where due to the upwelling of abysmal waters under the influence of the Humboldt current, the temperature of the water along the shore and for some miles to the westward ranges normally from 58° to 64° F. throughout the year. Coupled with this increase in temperature, which amounted on the average to 8° to 10° F., probably the direct cause of the change was an unusual southward extension of the comparatively little understood equatorial countercurrent known as El Niño,[2] (the child) because of its first appearance about Christmas.

A cross section of the ocean temperature observations made by Doctor Murphy and his assistant, Mr. Van Campen Heilner, during cruises in a gasoline launch off the Peruvian coast is given in the following table:

TABLE 1.—*Ocean temperatures (in degrees F.) recorded west of Peru and Ecuador during 1925*

[By Robert Cushman Murphy and Van Campen Heilner]

	Air	Water
Jan. 17:		
2:15 p. m.—Talara dock, 1 fathom		66
Talara dock, surface		66
2:35 p. m.—Harbor mouth, opposite point		67
3:15 p. m.—2 miles northwest of point, 2 fathoms		67.5
Continuous observations on southward arc, 3 miles from point, surface		67
4:35 p. m.—100 yards west of point		69
Jan. 19:		
1:05 p. m.—Harbor mouth, Talara		71
1:15 p. m.—½ mile north of Talara Head		72
1:20 p. m.—½ mile north of Talara Head		73
2:00 p. m.—Off Capullana Point		73
Numerous records over a course of 4 or 5 miles in the vicinity		73
3:00 p. m.—Harbor mouth		72
Jan. 20 (wind S. 40° W., fresh. Barometer at 1:55 p. m., 29.80):		
1:40 p. m.—Harbor mouth, Talara		74
2:10 p. m.—Pt. Pariñas bearing S. 30° E		76
2:25 p. m.—On course		76.5
3:00 p. m.—10 miles west of Talara		77
3:20 p. m.—On course		76.5
3:30 p. m.—On course		76.5
3:45 p. m.—12 miles west of Talara		77
4:10 p. m.—8 miles west of Talara		76
4:45 p. m.—200 yards outside Talara Head		75
Jan. 21 (barometer 29.85 at 10:25 a. m.):		
10:25 a. m	77	74.5
10:50 a. m.—1 mile from shore, outside Talara Head	78	74.5
11:20 a. m.—Off Point Pariñas	78.5	76
11:55 a. m.—1 miles west of Point Pariñas	75	75.5
1:05 p. m.—1 mile west of Point Pariñas	76	75.5
2:00 p. m	76	75.5
2:55 p. m.—4 miles west of Point Pariñas	76	75.5
3:30 p. m.—7½ miles west of Point Pariñas	76	75
4:05 p. m.—10 miles west of Point Pariñas	76	75.5
4:30-5:00 p. m.—12 miles west of Point Pariñas (continuous observation)		75.5-76
5:00 p. m.—15 miles west of Point Pariñas	76.5	76
5:40 p. m.—19 miles west of Point Pariñas	76.5	76
8:00-9:30 p. m.—Bound inshore, same course		75.5
Jan. 27:		
6:00 p. m.—Talara Harbor	81	78
6:15 p. m.—Outside Talara	79	77.2
7:20 p. m.—2½ miles west of Capullana Point	78	77
9:00 p. m.—Off La Cruz Bay	77	77
Jan. 28:		
7:50 a. m.—3-4 miles off shore, between Points Sal and Picos	75	78
9:30 a. m.—1 mile west of Point Picos	77	79.5
11:30 a. m.—2 miles off Zorritos	78	80
12:45 p. m.—4 miles off Malpasa Cove (green water)	78.5	81
3:15 p. m.—4 miles off Tumbes River	79	81
5:45 p. m.—Between Payana Point and El Muerto I	80	80.5
9:30 p. m.—Abreast outer end of Puná Island	78	77
Jan. 29 (Guayas River):		
6:30 a. m.—Just north of Puná village	77	81
8:00 a. m.—Near Isla Verde	74	81
9:45 a. m.—North of Punta Piedra	77	82
11:30 a. m.—Approaching Guayaquil	81.5	83
Feb. 11:		
1:15 p. m.—½ mile south of Ancon Point, Santa Elena	84.6	82
4:00 p. m.—¼ mile west of Point Santa Elena	81.5	81
Feb. 14:		
10:00 a. m.—Salinas (barometer 29.85)	82.2	
4:45-6:00 p. m.—Pelado Island to Salinas	77.5-78	79.5 / 80
Feb. 17: 8:00-10:30 a. m.—5 miles off Salango Island (numerous observations)		79
Feb. 21: 11:00-11:25 a. m.—From 1 mile west of Point Santa Elena to Chipipe beach (6 observations)	81	80
Feb. 26: 2:30-3:30 p. m.—Half way between El Muerto I. and southeast point of Puná Island, Gulf of Guayaquil	86	80.5
Mar. 3: 6:20 p. m.—200 yards west of Centinela Point, Puná Island	81.5	83
Mar. 4: 9:30 a. m.—5 miles off Zorritos, Peru	76	80.5
12:30 p. m.—3 miles off Punta Sal	76	80.5
4:45 p. m.—2 miles off Máncora Cove	78.3	81.5
7:00 p. m.—½ mile west of Cape Blanco	78.3	81.5
Mar. 5: 8:00 a. m.—1½ miles off Manta, Ecuador		77

El Niño Current observations.—On January 21, 1925, while the launch was anchored in 9 fathoms, 1 mile west of Point Pariñas (the western-most point of South America) the mean of five current observations showed its strength at that point to have been 1.2 knots.

After taking these observations the vessel headed westward for a distance of 19 miles. The current carried it well to the southward and appeared to be running with the same strength for the whole distance offshore.

According to the author, the northern waters of Peru are doubtless affected each year, and perhaps several times a year between December and April by incursions of the current from the north. An advance of pronounced intensity, however, seems to take place only a few times in a generation. In 1921 the countercurrent flowed with a strength which is still remembered, stranding palms, alligators and other tropical flotsam on the beach at Pacasmayo, and bringing such unfamiliar meteorological disturbances as thunderstorms far down the desert coast.[3]

In January of the present year Doctor Murphy observed the atmospheric changes that ushered in a period of heavy rains on the desert regions on the western slope of the Andes. The winds which in the Peruvian and Ecuadorian sectors of that slope and along the coast blow from the southeast and south and seldom stronger than a fresh breeze, now became northerly and the usual premonitory signs of precipitation appeared over the higher levels, gradually descending to the coast. The rains were heavy and fairly continuous—not of the shower type. No quantitative measures are available, but judged from the washouts, landslips, and finally by the cover of green vegetation which almost immediately sprang up, a very considerable amount must have fallen.

Corroborative evidence of the occurrence of rain and its southward extension to the Chilean provinces of Tarapaca and Antofagasta will be found in the summary of the

[1] Presented before the National Academy of Sciences, Washington, D. C., April 27, 1925.

[2] Cf. Murphy, Robert Cushman, Bird Islands of Peru, pp. 165 fig.; Coker, R. E., Ocean temperatures off the coast of Peru, Geographical Review vol. 5: 127-135.

[3] Loc. cit., footnote 1, Bird Islands of Peru.

weather in South America by Señor Julio Bustos Navarrete on pages 120-121 of this REVIEW.

Meteorologists will place a large ? over the region here considered and watch the course of future events with much interest.

Dr. Murphy plans to publish an account of his studies in a forthcoming number of the Geographical Review.—*A. J. H.*

THE SEVERE TORNADOES OF MARCH 18, 1925

The details of loss of life and property caused by the severe tornadoes that occurred in the great central valleys on March 18 will be found in the table of "Severe local hail and wind storms March, 1925" in this issue of the REVIEW. An account of the storms as meteorological phenomena will appear in the April, 1925, issue.—*Ed.*

NOTES, ABSTRACTS, AND REVIEWS

LOCAL BRIGHTNESS OF ULTRA-VIOLET LIGHT

By F. W. PAUL GÖTZ

[Abstract by H. H. Kimball, from Verhandlungen der Schweizer. Naturforschenden Gesellschaft, Luzern, 1924, S. 109-111]

The measurements were made with a cadmium photoelectric cell at Arosa, Switzerland, elevation above sea level 1,860 meters, with auxiliary stations, functioning at intervals, at Chur, elevation 590 meters, Hörnligrat (Skihütte), elevation 2,500 meters, and Aroser Rathorn, elevation 3,000 meters.

The summarized results concern themselves principally with the following:

(1) The intensity of ultra-violet radiation in the spectral regions $\mu\mu > 320$ and $\mu\mu < 320$.

(2) Systematic investigations relative to the influence of elevation.

Results of measurements of solar radiation show that ultra-violet of the longer wave lengths has less seasonal variation than the shorter wave lengths, and that the spring intensities about equal the fall intensities. With increased elevation of the sun, and likewise with increased altitude above sea level, the annual amplitude diminishes in both spectral regions, but does not vanish with extrapolation to zero atmosphere. This conclusion makes desirable a verification of the measurements, with an eventual extension of the research to the stars.

Ratio of intensity, Arosa: Chur

Solar altitude	10°	15°	20°	30°	40°	60°
Red-ultra-red	1.21	1.14	1.13	1.09	1.07	1.09
Ultra-violet>320μμ	3.52	2.79	2.04	1.53	1.49	1.48
Ultra-violet<320μμ	3.33	2.32	1.86	1.45	1.39	1.33

The greater weakening in the ultra-violet region $\mu\mu > 320$ was unexpected, and is not fully explained.

The dark sky of the high mountains gives rather more ultra-violet light than the brighter sky of lower levels. The skylight shows a linear relation to solar altitude down to about 13°.

At Chur, the sun, even with its highest position, yields less ultra-violet < 320 $\mu\mu$ than does the sky. At Arosa it first equals the skylight at 52° elevation. At 2,500 meters the equality occurs with solar altitude 45°.

Instead of defining the local brightness as the overlight (the light received on a horizontal plane from the sun and sky), it has been considered to be the light radiated to the entire surface of a sphere, or one-sixth the overlight plus the front light of four sides, plus the underlight. The author states that when we take into account the 100 per cent (?) reflection from snow this removes the disagreement between physical and physiological results emphasized on the medical side in the relative pigment-forming power of spring and autumn light.

MARVIN AND DAY ON NORMALS OF DAILY TEMPERATURE IN UNITED STATES [1]

ALFRED J. HENRY

The publication under review is the second revision of the daily normals of temperature for Weather Bureau stations throughout the United States. It contains the daily normals for 161 individual stations as computed by a method which is believed to be superior to that used in computing previous normals.

The explanation of the methods used in the analysis, as given by the authors follows:

A true normal daily temperature can be computed with entirely sufficient accuracy only from a long series of values of 24 hourly temperatures for each day, derived from the maintenance of automatically-recording thermometers.

While the Weather Bureau has records of this character covering periods of 20 years or more at many stations, these are insufficient in number to adequately represent the details of climatic conditions of a great area like the United States, the period of time covered by such data is too short, and especially the labor of computing normals from hourly readings is too enormous to justify their general use for that purpose. On the other hand, observations of the daily extremes of temperature are available for probably as many as 10,000 stations for periods ranging from a few years in many cases to 50 years or more in a considerable number of cases. In addition, other observations at stated hours are also available and serve to fix appropriate diurnal normals which are nearly identical with so-called true normals derived from 24-hourly readings. In presenting the present series of station normals based on daily observations of the maxima and the minima of temperature, the close relation between such values and those based on hourly readings will be indicated, at least for the United States.

Previous normals.—Bulletin R of the Weather Bureau, published in 1908, contained tables of the daily normal temperatures based upon a 33-year record, 1873 to 1905, inclusive. These daily values were obtained by charting on large sheets of cross-section paper the average temperature for each of the 12 months, drawing a smooth curve through these values, and scaling therefrom the approximate daily averages. This plan is objectionable in that each of the 12 points on the scale indicating the values for the respective months covered too great a period in days to enable the approximate location of the points of highest and lowest temperatures, or to give an adequate idea of the rates of change during the various portions of the months. Furthermore, the length of record at that time, 33 years only, is recognized as too short to give dependable values from computed actual daily means.

The monthly means used in computing the values appearing in Bulletin R were obtained from the tri-daily observations, 7 a. m., 3 p. m., and 11 p. m., 75th meridian time, for the period 1873 to June, 1888, inclusive, and from the mean of the daily maximum and minimum temperatures from July, 1888, to the end of 1905. As the observations at stated hours were necessarily made at the same moment of time over all portions of the country, there was a constant and increasing earlier occurrence of the hours of observation to the westward. That is, at the first observation of the day, made at 7 a. m., say, for Philadelphia; the local time of observation at St. Louis would be an hour earlier, or 6 a. m.; at Denver it would be 2 hours earlier, or 5 a. m., and in California 3 hours earlier, or at 4 a. m.; the same conditions apply to the other observations. The means obtained from these data are, therefore, not strictly homogeneous throughout all parts of the country, due to the earlier hours of observation over the western portions.

In the early days of the service the means determined from the maximum and minimum readings were mainly worked out after the last observation of the day, usually 11 p. m. Later, when self-

[1] Marvin, C. F., and Day, P. C., Normals of temperature for the United States, 46-year period, July 3, 1875, to July 2, 1921, MONTHLY WEATHER REVIEW SUPPLEMENT No. 25, Washington, 1925.

recording instruments were introduced, the extremes were determined from midnight to midnight, local standard time. As both the maximum and minimum temperatures for the day usually occurred before the last observation, it is thought no important differences exist in the resulting means obtained from these readings over the different parts of the country.

With nearly 50 years of record now available for many stations it is possible to compute averages with considerable accuracy and the mean daily values submitted herewith are based upon averages uniformly determined from the daily extremes, and covering the period July 3, 1875, to July 2, 1921, 46 years of record. This series of means, unlike any previously used, as stated above, is practically homogeneous throughout the period of years considered, and the data from all parts of the country are placed upon a strictly comparable basis. The differences between the means obtained from the daily extremes and the true means, determined from hourly observations throughout the entire 24-hour period, are materially affected by local topography, distance from large bodies of water, etc. These differences were carefully analyzed by Professor Bigelow, appropriate corrections to the 24-hour means determined by him, and set forth by charts in Bulletin S of the Weather Bureau. The charts [not reproduced here.—*A. J. H.*] show how small the corrections generally are for the continental United States; on account of this smallness they have not been incorporated in the present tables.

Terminal adjustment.—Every complete cycle like the annual march of temperature must, of course, close upon itself, that is, the normal value for a given day at the beginning of the cycle must be identical with the value for the same day one year later. Average values for corresponding days even when derived from a long series of observations rarely or never satisfy this requirement. Quite a common practice among students in such cases consists in adjusting the two terminal values of the cycle to identity by distributing the discrepancy proportionately to all intermediate values of the whole series. This practice really has no physical basis of justification whatever in the case of many years of observations, because the discrepancy in question is characteristic of only a few values of the data immediately contiguous to the terminal values. Therefore, it is best in such cases to make no correction at all for terminal inequality, but to begin and end the cycle at a time when conditions fluctuate the least, that is, the summer season in the present case. Any outstanding discrepancy in the data itself will then be best disposed of by the subsequent mathematical analysis or by the drawing of smooth curves if that method is employed.

Choice of phase interval.—The superior advantages of the week as a sub-unit for the detailed analysis of the annual march of temperature are largely self-evident and were convincingly presented by one of the writers in the MONTHLY WEATHER REVIEW, August, 1919, 47: 544–555. Accordingly, this unit was adopted and daily averages of the maximum and minimum temperatures were prepared separately at all stations having 20 years of record or more. From these, weekly averages were computed. Although the schedule of weeks begins with January 1 to 7, so as to fit the calendar year, the tabulation of the data was made to begin with the week comprising the days July 3 to 9, so as to avoid the large terminal discrepancies which arise from a tabulation by calendar years. In leap years, the temperature for the 29th day of February was merged at ¼ weight with the week naturally comprising that date. Furthermore, the extra day over 52 weeks in all years was merged as an 8th day in the week beginning April 16. This date was chosen because the mean temperature for the year occurs about at this time and the inclusion of the extra day then would make the mean of the 52 weekly values of the data most nearly identical with the mean of the 365 individual days.

On account of the varying dates attending the beginning of observations at the respective stations it was considered that all stations having from 40 to 45 years of record were of sufficient length to give normals that would not be appreciably changed by the addition of the few years necessary to complete the full 46-year period. Of the stations appearing in the following tables, 93 had lengths of record varying from 40 to 46 years; the remainder, or 71, had lengths of record ranging from 20 to 39 years, and in these cases the records were corrected to the full 46-year period by the usual methods employed in such cases, that is, by comparing the shorter series with similar periods for near-by points and determining and applying the corrections necessary to reduce the weekly values to the full period of 46 years.

In accordance with the plan described in the foregoing, there were derived 52 weekly values of maximum and minimum temperatures for a total of 164 stations, well distributed over the continental United States and including the stations at Honolulu and San Juan, all (except the two last mentioned) adjusted to a period of 46 years. These constitute extremely valuable basic meteorological data and it is contemplated to publish them separately in full, together with a discussion of the residuals from the harmonic analysis and smooth curves.

METHODS OF ANALYSIS

Two methods were employed to derive daily normals from the weekly averages.

First method.—For the 93 stations having 40 or more years of records, the weekly means were subjected to a four-term Fourier analysis and 52 values of normal temperatures were computed therefrom. These, of course, were separated from each other by an exact interval of $7\frac{1}{52}$ days. By an appropriate and progressive adjustment these computed values were transformed to 52 values at intervals of exactly 7 days, except that the 52d week, beginning June 26, was made to contain 8 days.

It is considered unnecessary to outline the arithmetical processes followed in computing these weekly values, but they are recognized as superior to the methods usually followed in drawing free-hand curves through the observed data. From these weekly normals intermediate daily values were easily interpolated for both the maximum and minimum separately. The mean of the two normal extremes is considered to give a normal daily mean temperature of great significance, and these are the values given in the accompanying tables.

Second method.—For stations with a length of record from 20 to 39 years the final daily values of the normal maximum and the normal minimum temperatures were obtained by drawing smooth curves through the 52 weekly averages and scaling the daily values therefrom, similar to the manner of obtaining the data given in Bulletin R previously explained, save that the number of points available for plotting was increased from the 12 mean monthly values to 52 means for the respective weeks, the increase in the number of points affording opportunity to produce a curve upon which could be located with considerable accuracy the extreme points, and the proper rate of change in the varying portions of the month.

This supplement is not for general free distribution. It will be sent free to cooperating meteorological services and institutions, and to individuals and organizations that have cooperated with the Bureau in this research. Copies of the Supplement may be had from the Superintendent of Documents, Washington, D. C., at the price of 20 cents. Remittances should be made to that official and not to the Weather Bureau.

COTTON GROWING IN RELATION TO CLIMATE IN EGYPT AND THE SUDAN

[Abstracted by J. B. Kincer from Technical and Scientific Service Bull. No. 47, of the Ministry of Agriculture, Egypt]

In 1923, the Ministry of Agriculture of Egypt published a report by Mr. C. B. Williams on the cotton plant in relation to temperature and rainfall, (Technical Bulletin No. 32, Cairo), which was abstracted for the June, 1924, number of this Review, pages 306 and 307. In a more recent bulletin (No. 47, 1924), the same author treats of climatic conditions and their relation to the growth of cotton in Egypt and the Sudan. The climatic factors considered are temperature, moisture, wind, and light.

This study is of unusual interest because of the fact that cotton in Egypt, grown principally in the extreme lower Nile Valley, is a summer crop, while in the Sudan, extending from the central and southern districts of the Red Sea westward to the upper Nile Valley, it is grown as a winter crop. In Egypt the seeds are planted on a rising temperature, usually when the mean daily values rise to about 60°, while in the Sudan they are planted on a falling temperature, ranging from 90° to 80°. The lowest temperature of record at any of the Egyptian stations in the cotton area is 25°, while in the Sudan the lowest of record is 37°, and by reason of the difference in the time of the cotton season, the growing plants escape the extreme cold in Egypt and the extreme heat of the Sudan.

In both sections cotton is mainly, but not entirely, dependent upon irrigation. There are a few places in the southern Sudan where it is grown under natural

rainfall, and in a few other low-lying parts irrigation is not practiced, but in these cases percolation takes place from the surrounding country. In some cases the crop is dependent on the flood waters of the rivers, and in others on the artificial application of moisture. Because of the fact that evaporation is high in regions where irrigation must be practiced, this factor is given considerable attention; in Egypt, cotton is produced at the time of greatest evaporation, and in the Sudan at the time of the least.

Mr. Williams makes the following comments on the number of hours of daylight under which cotton is grown in the two sections:

Recent investigations have shown that the number of hours of daylight to which a plant is exposed may have great influence on its periods of growth and maturity. Without wishing to make any statement as to whether or not cotton is so influenced, it may be of interest to put on record on the same form of diagram the actual number of hours of daylight in the different localities in the different stages of the crop.

The figure for any month is of course directly dependent on the latitude of the locality. And in view of the more or less proportional changes, the value for only two localities in Egypt and two in the Sudan have been shown.

They show that while the Sudan has the most hours of daylight in the close season, during the growing period the cotton here has two to three hours a day less than in Egypt. As the Sudan is probably the furthest locality from the Equator at which cotton is grown as a "winter" crop, it is probable that these figures represent the shortest hours of daylight under which cotton is cultivated.

The longest hours will probably be found in the few small localities in Bulgaria where cotton is grown as a summer crop in a atitude of 40° north.

The greatest similarity of conditions between Egypt and the Sudan is found at the time of planting and again at about the middle of picking.

USE OF THE BEAUFORT SCALE OF WIND BY THE UNITED STATES WEATHER BUREAU

The Beaufort Scale, with certain changes which have varied from time to time, has been in use by the Bureau since 1905 except for the years 1909–1914, during which a 7-point scale was used. Though this scale was based on the Beaufort Scale, its use nevertheless constituted a virtual abandonment of the Beaufort notation. When the fourth edition of the Smithsonian Meteorological Tables, published in 1918, was in preparation, under the supervision of the Weather Bureau, the table of the Beaufort Scale containing equivalents according to Scott, which appeared in the third edition, was replaced by a a table taken from the Observers' Handbook of the British Meteorological Office, containing the equivalents as determined by Simpson. This was done because the Simpson values appeared to rest upon a more satisfactory experimental basis than any others available.

Use of the Beaufort Scale had been resumed by this Bureau in 1914, but experience has since demonstrated that for purposes of forecast terminology in this country the Beaufort Scale numbers are too numerous and too restrictive in velocity ranges to be practicable. Therefore, to meet the needs of the forecaster and at the same time to retain for other purposes the advantages of the full Beaufort notation, the scale as given herewith was put into effect on January 1, 1925. This brings the scale as now used into harmony with that in the revised Smithsonian Meteorological Tables. As stated in the report of the committee of this Bureau on revision of the scale:

It appears that while the version of the Beaufort Scale now used by the British Meteorological Office, with anemometric equivalents determined by Simpson, has not been formally adopted by other countries, it has a certain degree of international authority on account of its incorporation in the English edition of the International Meteorological Codex, and, on account of the preponderance of British shipping, it is probably more widely used by mariners than any other. The increasing cooperation between the United States and England in the exchanging of vessel reports; the fact that England was the originator of the scale and has done more than any other nation in scientific correlation of the scale values to anemometry records were also considered as justifying the U. S. Weather Bureau in adopting the Beaufort Scale (Simpson) as used by England.

Beaufort scale of wind, with velocities and descriptive terms

Beaufort No. (a)	Explanatory titles (b)	Mode of estimating aboard sailing vessels (c)	Specifications for use on land (d)	Miles per hour (statute) (e)	Terms used in U. S. Weather Bureau forecasts (f)
0	Calm		Calm; smoke rises vertically.	Less than 1	Light.
1	Light air	Sufficient wind for working ship.	Direction of wind shown by smoke drift, but not by wind vanes.	1–3	
2	Slight breeze		Wind felt on face; leaves rustle; ordinary vane moved by wind.	4–7	
3	Gentle breeze		Leaves and small twigs in constant motion; wind extends light flag.	8–12	Gentle.
4	Moderate breeze	Forces most advantageous for sailing with leading wind and all sail drawing.	Raises dust and loose paper; small branches are moved.	13–18	Moderate.
5	Fresh breeze		Small trees in leaf begin to sway; crested wavelets form on inland waters	19–24	Fresh.
6	Strong breeze	Reduction of sail necessary with leading wind.	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	25–31	Strong.
7	High wind		Whole trees in motion; inconvenience felt in walking against wind.	32–38	
8	Gale	Considerable reduction of sail necessary even with wind quartering.	Breaks twigs off trees; generally impedes progress.	39–46	Gale.
9	Strong gale		Slight structural damage occurs (chimney pots and slate removed).	47–54	
10	Whole gale	Close reefed sail running, or hove to under storm sail.	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	55–63	Whole gale.
11	Storm		Very rarely experienced; accompanied by widespread damage.	64–75	
12	Hurricane	No sail can stand even when running.		Above 75	Hurricane.

December, 1924.

The following historical note by Prof. C. F. Talman on the origin and evolution of the Beaufort Scale, and on the extent to which progress has been made toward giving it international official sanction, is here reprinted from the report of the same committee:

The Beaufort Scale of wind force was introduced by Sir F. Beaufort in 1805 for use on shipboard, and has been more extensively employed than any of the several other scales devised for the noninstrumental observation of wind force. In 1874, it was adopted for international use in weather telegraphy by the Permanent Committee of the First International Meteorological Congress (the predecessor of the present International Meteorological Committee).

The first actual comparisons between anemometer readings and estimates made according to the Beaufort Scale appear to have been those carried out by R. H. Scott on the English coast, beginning in 1869, though several lists of equivalents of the Beaufort numbers in miles per hour or meters per second had been published previously to that time; viz, by Sir Snow Harris, Sir H. James, Fitz-Roy, Schott, Symons, Jelinek, Neumeyer, and Laughton. The values obtained by Scott were published in the Quarterly Journal of the Royal Meteorological Society, vol. 2, 1874, pp. 109–123. They were adopted by the British Meteorological Office, which used them until 1909, and were also incorporated in many reference books, including the Smithsonian Meteorological Tables. Scott's values are now known to have been seriously in error, on account of his use of the reduction factor 3 in connection with the anemometer reading, as well as for other reasons.

Several later series of comparisons have been made, viz, by Mohn, Chatterton, Curtis, Sprung, and Köppen, and finally by Doctor Simpson, the present director of the British Meteorological Office, whose results were published by that office in 1906 and are now used officially in England.

At the London, 1912, meeting of the International Committee for Weather Telegraphy, Professor Palazzo raised the question of

international agreement on the anemometric equivalents of this scale, with reference to its use in weather telegraphy, and a committee was appointed to prepare a report on the subject. This committee reported at the Rome, 1913, meeting of the International Meteorological Committee. A report of this meeting (Appendix 7) contains a résumé of the various wind scales in use and the anemometric equivalents recognized by various countries. The wind-scale committee recommended that the International Committee should adopt a set of equivalents in meters per second and in miles per hour (published on p. 36 of the appendix above mentioned), approximating the Simpson scale, though not agreeing with it exactly. The International Committee decided, however, that it was not yet practicable to adopt an international set of equivalents, and referred the subject back to the special committee for further consideration. In 1915 the Russian Meteorological Service announced that it had adopted a set of equivalents based on the English table, in conformity with the decisions of the Rome meeting of the International Committee (Monthly Weather Review, April, 1915, p. 183), but the announced equivalents do not exactly agree either with those of Simpson or with those proposed at the Rome meeting for international use. This subject was revived at the London, 1921, meeting of the International Committee, and Doctor Simpson was asked to undertake further investigation of the subject, which he agreed to do. This action is briefly mentioned in the report of the International Meteorological Conference held at Utrecht in 1923, but there is no record of further progress in the matter.

It would appear to be most desirable that the question of international adoption of the Beaufort Scale should form a subject for definitive action at the next meeting of the International Meteorological Committee. The extent to which the scale is recognized unofficially will, it is believed, constitute an important step toward such international adoption.—*B. M. V.*

FREQUENCIES OF SELECTED RELATIONS BETWEEN TEMPERATURE AND RELATIVE HUMIDITY

Dr. Moriz Topolansky presents in *Das Wetter* for January, 1925, pp. 21–23, an interesting method of setting forth certain relations between these two important climatic elements.

He plots for Vienna (years 1919–1923) the frequencies of simultaneous occurrence of selected 2 p. m. temperature and relative humidity values. Temperatures are grouped in successive 5 degree ranges and relative humidities in successive 5 per cent ranges.

Temperature-relative humidity relations at Vienna (2 p. m. values, years 1919–1923)

(Frequencies of simultaneous individual values)

Relative humidity (per cent)	Temperature, °C. −10	−5	0	5	10	15	20	25	30	35	Sums
100–95			13	29	6	4					52
95–90			13	36	18	11	5				83
90–85		2	20	33	26	19	13				113
85–80		4	15	35	34	14	14	2			118
80–75		3	19	33	32	22	25	4			138
75–70		3	11	30	29	30	26	10			139
70–65		4	8	24	39	28	25	17	2		147
65–60		1	8	33	30	29	36	38	4		179
60–55		2	9	22	26	31	38	44	8		180
55–50		4	4	8	36	32	44	55	13		196
50–45			5	8	20	25	37	50	19		164
45–40			5	5	15	26	35	35	16	1	138
40–35				4	7	19	18	25	17	4	94
35–30					5	9	8	15	13	5	55
30–25					4	2	7	3	7	4	27
25–20						2	1				3
Sums		23	130	300	327	303	332	298	99	14	

Though this general method of depicting climate necessarily omits important climatic elements—perhaps wind movement is in this case the most important—nevertheless it would doubtless prove of value to many of those concerned with the physiological relations of climate.

One finds concentrated in a table of this sort many facts otherwise to be presented only at considerable length. Thus it is at once clear that at Vienna cool to moderate early afternoon temperatures are accompanied by nearly every possible relative humidity; temperatures near freezing have a tendency to be accompanied by considerable dampness; high temperatures are almost never accompanied by high humidity. Other relations are equally patent from the table.—*B. M. V.*

THE MARCH, 1925, POSITION OF THE GULF STREAM AND THE LABRADOR CURRENT

The following note, taken from the Coast Guard Weekly Bulletin No. 16–25, dated April 18, 1925, is of especial interest in connection with the note in this REVIEW for February, 1925, on the extraordinarily mild winter of 1924–25 in northwestern Europe.

The scientific observations made during the first cruise of the *Tampa* on the international ice patrol divulged some interesting facts. One of the most striking was the decided movement upward [northward] of the "cold wall" and another is the disappearance of the 32° line on the southern part of the Grand Banks with only a slight touch of cold water along the 44th parallel. It is very evident that the Labrador current is very weak, and that the influence of the Gulf Stream is felt farther north even to the extent of overlapping on the Banks. The absence of Arctic water, the weakness of the Labrador current, the overwhelming effect of the Gulf Stream, and the mild winter conditions off the coast of Labrador, etc., have no doubt been responsible for the total absence of bergs below latitude 46° to date. From March 26 to 31 the patrol vessel encountered about 50 per cent fog.

AMUNDSEN'S SHIPS REACH SPITZBERGEN

Press reports under date of April 25, 1925, indicate that the two supporting ships of Amundsen's airplane expedition to the North Pole have reached King Bay, Spitzbergen, thus giving evidence of an exceptionally open season in that sector of the Arctic. Usually that region can not be reached before the latter part of May at the earliest.—*A. J. H.*

NEW CHIEF OF THE SERVICIO METEOROLOGICO ESPAÑOL

Word has been received at the U. S. Weather Bureau, under date of March 20, 1925, announcing the withdrawal of Señor J. Cruz-Conde from his position as Chief of the Spanish Meteorological Service, a step made necessary by his appointment to an important Government post not connected with meteorology. His successor as head of the Meteorological Service is Señor Enrique Meseguer.

METEOROLOGICAL SUMMARY FOR FEBRUARY AND MARCH, 1925: CHILE, ARGENTINA, BOLIVIA, PERU, URUGUAY, AND PARAGUAY.

[Reported by Señor Julio Bustos Navarrete, Director, El Salto Observatory, Santiago, Chile. Translated by W. W. Reed, U. S. Weather Bureau, Washington]

February.—The first 15 days of the month were characterized in Chile by the establishment of an important center of high pressure opposite the coast of Arauco Province. The pressure remained low southward to Magellanes Province, frequent depressions being observed.

This condition caused persistent rains in the provinces of Cautin, Valdivia, Llanquihue and Chiloe.

In Argentina, heavy rains and electrical storms occurred in the northern and central parts during the 9th, 10th, and 11th.

In Bolivia, very heavy rains took place during the 14th, 15th, and 16th. These rains extended into the southwest, causing severe floods in the Chilean provinces of Tarapaca and Antofagasta. The Rio Loa rose to extraordinary stages, doing severe damage to various towns and nitrate factories.

On the 16th an important barometric depression appeared from the west approaching South America off the central region of Chile. On the 17th, a pronounced fall of pressure took place in the Islands of Juan Fernandez, and on the 18th the depression began to affect the continent. On the 19th there were scattered rains between Valparaiso and Valdivia. On the 20th, the depression continued its southward progress, and abundant rains occurred between the provinces of Cautin and Magellanes.

In Argentina, during the 19th and 20th, a great depression existed in the northern region, and caused violent wind storms with lightning and thunder, rain, and hailstones of large size.

During the later days of the month a notable rise of pressure took place in southern Chile, resulting in the establishment of an anticyclonic center in the latitude of Chiloe, and the return of atmospheric conditions to normal.

March.—The outstanding meteorological feature was the frequency of disturbances in the southern region of the continent.

During the first days of the month pressure was high over northern Argentina and Uruguay. At this time light rains fell in the southern part of the province of Buenos Aires and in the territory of Rio Negro; electrical storms, with hail, occurred in central La Pampa on the 3d.

From the 4th to the 6th an area of high pressure formed in the region of Chiloe. On the 7th a V-shaped depression was accompanied by electrical storms, rain, and hail in Chilean provinces from Colchagua to Malleco.

A depression appeared in the south off Cabo Raper on the 10th; it caused rains over the whole southern region on the 11th and 12th.

A moderately heavy snow fell in Magellanes on the 15th.

During the following days an anticyclone formed in the south and this condition remained until the 26th; during this period a maximum pressure of 770 mm. (30.32 inches) was recorded at Puerto Madryn on the Atlantic coast.

Scattered rains fell in Argentina on the 24th and again from the 28th to the 30th.

A depression from the west appeared off central Chile on the 27th; on the next day it affected conditions in the south, bringing violent electrical storms, with rain and hail, in the provinces from Bio-Bio to Chiloe. During the following days it moved away toward the south, its path passing near the South Shetland and South Orkney islands into the antarctic glacial sea.

On the whole the month of March was more rainy than normal in southern Chile. In Argentina and Urguay rains were frequent and in Bolivia and the high regions of Peru they were rather abundant.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, Meteorologist in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies;

Brooks, Charles F.
Some striking displays of coronas and iridescent clouds. 12 p. 28½ cm. [Typewritten.]

Dole, Eleazer J.
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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING MARCH, 1925

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, **52**: 42 and January, 1925, **53**: 29.

From Table 1 it is seen that solar radiation intensities averaged somewhat above normal values for March at Washington and Lincoln, and somewhat below at Madison. A noon reading of 1.55 gram-calories per min. per cm² at Lincoln on the 14th almost equals the previous March maximum at that station of 1.56. A note on the original record reads "The high wind with snow yesterday [March 13] seems to have cleared the air to an exceptional degree."

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged below normal at Lincoln and slightly above normal at Washington and Madison.

At Washington skylight polarization measurements made on five days give a mean of 56 per cent, with a maximum of 65 per cent on the 19th. These are close to normal values for March at Washington. At Madison, measurements made on six days give a mean of 56 per cent with a maximum of 63 per cent on the 26th. These are slightly below normal values for March at Madison.

TABLE 1.—*Solar radiation intensities during March, 1925*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m.	Sun's zenith distance									Noon
		78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Mar. 3	1.32		0.64	0.89	1.14	1.43					1.12
6	4.75			0.84	1.06		1.05	0 95	0.76	0.64	3.81
12	4.95	0.68	0.79	0.97	1.23	1.57	1.33	1.14	1.02		3.45
16	3.00		0.62	0.82	1.02						2.36
19	12.24						1.15	0.96			8.18
20	3.81		0.88	1.04	1.18						4.57
21	5.79	0.54	0.71	0.89	1.09						5.36
23	3.00	0.88	1.02	1.14	1.31	1.50	1.32	1.01	0.92	0.72	2.87
Means		0.70	0.77	0.94	1.15		1.21	1.02	0.90	(0.68)	
Departures		−0.01	−0.03	±0.00	±0.00		+0.09	+0.09	+0.10	±0.00	

TABLE 1.—*Solar radiation intensities during March, 1925*—Contd.

Madison, Wisconsin

Date	8 a.m.	Sun's zenith distance									Noon
		78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Mar. 2	0.53					1.57	1.30				0.81
10	5.16				1.21						4.17
12	2.16		0.83	0.95	1.20	1.41	1.05				3.45
23	3.99						0.68				5.79
24	6.76						1.33	1.18			5.16
26	5.16			0.95	1.07						6.27
28	3.00		1.10	1.21	1.37	1.55					3.15
30	3.81						1.20				4.75
31	3.30			1.17	1.37		1.17				2.87
Means			(0.96)	1.07	1.24		1.12	(1.18)			
Departures			−0.07	−0.11	−0.08		−0.18	+0.01			

Lincoln, Nebraska

Date	8 a.m.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	Noon
Mar. 2	1.12		1.14								1.37
5	4.75	0.70	0.80	0.99	1.17	1.42					0.27
14	1.32		1.04	1.19	1.42	1.70	1.37	1.00			1.60
18	3.30					1.52	1.25	1.07	0.89	0.76	3.81
19	3.99	0.94	1.06	1.20	1.40	1.64	1.39	1.19	1.04	0.92	2.49
21	3.00		1.04	1.17	1.33	1.50					3.00
24	5.16					1.46	1.25	1.06	0.90	0.76	5.36
25	4.57		1.01	1.12	1.28	1.48	1.28	1.10	0.95	0.82	4.37
26	3.30		0.79	0.99	1.25		1.13	0.95	0.80		2.87
27	2.62	1.01	1.12	1.24	1.41	1.56	1.34	1.14	1.02	0.90	1.96
30	3.00		1.07	1.17	1.36	1.57					2.49
Means		0.88	1.01	1.13	1.33		1.29	1.07	0.93	0.83	
Departures		±0.00	+0.07	+0.04	+0.04		+0.02	±0.00	±0.00	+0.04	

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation					Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Washington	Madison	Lincoln
	cal.	cal.	cal.	cal.	cal.	cal	cal.	cal.
Feb. 26	361	293	310	208	252	+80	+11	−31
Mar. 5	304	229	325	148	242	−2	−77	−39
12	295	298	332	184	265	−42	−26	−60
19	459	355	457	255	366	+101	+13	+45
26	243	445	427	331	180	−132	+86	−1
Excess or deficiency since first of year on Apr. 1, 1925						−1,099	−1,785	−1,302

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The following table shows the average sea-level pressure for the month at a number of land stations on the coast and the islands of the North Atlantic. The readings are for 8 a. m., 75th meridian time, and the departures are only approximate, as the normals are taken from the Pilot Chart and are based on Greenwich mean noon observations, which correspond to those taken at 7 a. m., 75th meridian time.

Station	Average pressure	Departure
	Inches	*Inches*
St. Johns, Newfoundland	30.09	+0.23
Nantucket	30.08	+0.08
Hatteras	30.10	+0.07
Key West	30.07	+0.04
New Orleans	30.13	+0.10
Swan Island	29.93	−0.06
Turks Island	30.04	+0.02
Bermuda	30.12	+0.09
Horta, Azores	30.11	−0.01
Lerwick, Shetland Islands	29.99	+0.29
Valencia, Ireland	30.34	+0.44
London	30.18	+0.22

It will be seen from the above table that positive departures were the rule at all the stations with the exception of Horta and Swan Island. The North Atlantic LOW was apparently not far from the normal, while the average pressure on the coast of northern Europe was considerably higher than usual, indicating that the Icelandic LOW was comparatively inactive. At Lerwick the barometric readings ranged from 29.29 inches on the 24th to 30.45 inches on the 3d and 11th, and at Horta from 29.82 inches on the 8th and 9th to 30.40 inches on the 25th and 26th.

Taking the ocean as a whole the number of days with winds of gale force did not differ materially from the normal as shown on the Pilot Chart, and they were also comparatively evenly distributed, although the number of gales reported from vessels in the middle section of the steamer lanes and along the American coast was slightly in excess of those encountered elsewhere.

The number of days with fog was apparently nearly normal over the Grand Banks and in the vicinity of the American coast. It was reported on from 1 to 3 days off the coast of northern Europe and also in the Gulf of Mexico, while the middle section of the steamer lanes was comparatively clear.

The month began with two depressions over the ocean, the first central about 5 degrees south of Hatteras, and the second near 47° N., 35° W. The western LOW moved northeastward along the coast and on the 3d was over Newfoundland. Moderate to strong gales accompanied by hail and snow were encountered during the period from the 1st to 3d over the region between the Bermudas and the 45th parallel, the storm area reaching its greatest extent on the 3d. The second disturbance also apparently moved in a northeasterly direction, although it was impossible to plot the track, due to lack of observations. Reports of gales on the 2d, were received from vessels in the steamer lanes east of the 40th meridian, while on the 3d they were restricted to the region between the 10th meridian and French coast.

On the 4th there was a well defined and comparatively deep depression central near 32° N., 25° W., with moderate to strong easterly gales prevailing between the 30th parallel and the Azores. This LOW drifted slowly eastward, decreasing in intensity, and on the 5th and 6th was over the region between Madeira and Gibraltar, where it gradually filled in.

On the 5th there was a LOW a short distance east of Charleston which afterwards developed into a severe disturbance that prevailed on the 6th and 7th between the 30th and 40th parallels and the 65th meridian and American coast.

On the 10th there was another depression central near 30° N., 53° W., that moved but little during the next 3 days, and reached its greatest intensity on the 11th, when northeasterly gales prevailed between the Bermudas and the 50th meridian. Charts VIII to XIII show the conditions from 11th to 16th, inclusive

On the 11th there was a LOW central near 50° N., 35° W., that moved rapidly northeastward and was somewhere in the vicinity of Iceland on the 12th, where low pressure prevailed until the 18th, although it was impossible to show the conditions accurately due to lack of vessel reports from these waters.

Charts IX, X, and XI, for the 12th, 13th, and 14th, respectively, show the disturbance over the eastern sections of the southern steamer lanes, and Chart XII gives an idea of the conditions that prevailed along the American coast on the 15th.

From the 14th to 18th there was a depression in the vicinity of Madeira, of limited extent and of slight intensity, except on the 17th, as shown by the report from the French S. S. *El Kantara,* in the table.

From the 16th to 24th comparatively high pressure prevailed over the greater part of the ocean and during this period northerly to easterly winds of gale force, accompanied by comparatively high barometer readings were encountered over the western and middle sections of the steamer lanes.

On the 17th moderate southerly gales were reported from the vicinity of Hatteras.

On the 23d there was a LOW over the Strait of Gibraltar with moderate northerly to northeasterly winds that increased to gale force by the following day.

On the 25th a well developed depression was central near 33° N., 55° W., and moved about 10 degrees eastward during the next 24 hours, and then curved sharply towards the northeast. On the 27th the center was near 45° N., 42° W.

On the 28th New York was near the center of a depression that moved slowly east-southeastward, and on the 31st, when at its greatest intensity, was central about 5 degrees north of the Bermudas. On the 28th northwesterly gales were encountered in the vicinity of Charleston, although moderate weather was the rule along the remainder of the American coast.

Ocean gales and storms, March, 1925

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
North Atlantic Ocean			° ′	° ′				Inches					
Eldena, Am. S. S.	Galveston	Bremen	35 05 N.	74 22 W.	1st	3 p., 1st	1st	29.65	ESE	S., 11	WSW	S., 11	S.-W.
Dio, Am. S. S.	Tampa	Barcelona	38 10 N.	62 30 W.	2d	Midt., 2d	4th	29.67	SSW	S., 7	SSW	SW., 11	S.-SW.
Lackawanna, Br. S. S.	New York	Birkenhead	46 35 N.	38 19 W.	1st	7 p., 1st	3d	29.34	NW	NW., 8	SE	NNW. 11	NW.-N. SE.
Cripple Creek, Am. S. S	Galveston	Genoa	39 36 N.	25 46 W.	3d	2 p., 3d	6th	30.01	SE	SE., 7	E	E., 9	SE.-E.
Carlton, Am. S. S.	do	Gibraltar	35 30 N.	72 15 W.	5th	7 p., 5th	7th	29.82	SSE	SSE. 7	E	ESE., 11	Steady.
Nubian, Br. S. S.	do	Liverpool	32 53 N.	73 56 W.	5th	3 p., 6th	6th	29.60	N	N., 6	NE	N., 12	NNW.-N.
Wellfield, Br. S. S.	London	New Orleans	31 51 N.	53 50 W.	10th	Midt., 10th	11th	29.50	SW	SW., 3	NNE	NNE., 8	Steady.
Hellig Olav, Br. S. S	Oslo	Halifax	55 32 N.	30 10 W.	11th	6 p., 11th	12th	29.50	S	SSW., 9	W	SSW., 9	S.-SW.-W.
El Kantara, Fr. S. S.	Marseille	Colon	35 50 N.	6 05 W.	13th	13th	13th	29.73	E	E., 10	SE	E., 10	Steady.
Bolton Castle, Br. S. S	Algiers	New York	34 08 N.	18 30 W.	12th	3 a., 13th	13th	29.71	NE	NE., 9	N	NE., 9	NE.-N.
Am. Trader, Am. S. S.	New York	London	42 07 N.	61 00 W.	14th	7 a., 15th	15th	29.75	SSW	WSW., 7	NW	SSW., 9	SW.-W.
Hera, Am. S. S.	Baton Rouge	Marseille	33 32 N.	56 18 W.	16th	6 p., 16th	17th	30.35	NE	NE., 7	NE	NNW., 9	NE.-E.
El Kantara, Fr. S. S.	Marseille	Colon	30 37 N.	23 05 W.	15th	17th	19th	29.47	SSE	S., 9	W	SW., 10	
Bolton Castle, Br. S. S	Algiers	New York	32 58 N.	42 00 W.	17th	9 p., 17th	19th	30.12	N	N., 8	NNE	NNE., 9	Steady.
Minnewaska, Br. S. S	New York	London	45 04 N.	35 41 W.	18th	10 p., 18th	19th	30.13	NE	NE., 9	E	NE., 9	NE.-ENE.
Andania, Br. S. S.	do	Plymouth	42 50 N.	41 40 W.	18th	6a., 19th	21st	30.23	NW	NNE	ENE	N., 10	NE.-N.-NE.
Howick Hall, Br. S. S	Norfolk	Liverpool	43 17 N.	41 00 W.	19th	4 p., 21st	23d	30.07	NNE	E	ESE	NE., 9	ENE.-E.
Barendrecht, Du. S. S.	New Orleans	Barcelona	38 56 N.	32 36 W.	22d	4 a., 22d	23d	29.85	E	E., 7	ESE	E., 9	E.-ESE.
Antinous, Am. S. S.	Liverpool	Mobile	35 54 N.	35 06 W.	22d	4 a., 24th	24th	29.82	SE	SE	S	E., 8	E.-SE.
Clan Malcolm, Br. S. S.	Fremantle	Dunkirk	37 04 N.	9 00 W.	24th	6 a., 24th	24th	29.90	NNE	N., 8	NNE	—, 9	Steady.
Cynthiana, Br. S. S.	Philadelphia	Lisbon	40 00 N.	57 00 W.	24th	8 a., 25th	25th	29.94	NE	NE., 10	NE	NE., 10	Steady.
West Gotomska, Am. S. S.	Copenhagen	Baltimore	37 10 N.	42 33 W.	26th	9 a., 26th	27th	29.41	SW	SW., 9	W	SW., 9	S.-W.-WSW.W.
Maine, Dan. S. S.	Newcastle	Havana	42 24 N.	38 46 W.	26th	8 a., 27th	28th	29.72	SE	SE., 9	SSW	SE., 9	SE.-S.-SSW.
Gulfcoast, Am. S. S.	Port Arthur	Savannah	30 30 N.	79 40 W.	27th	9 p., 27th	28th	29.77	NW	NW., 10	NW	NW., 10	Steady.
Madonna, Fr. S. S.	Lisbon	Providence	38 30 N.	61 20 W.	29th	2 p., 29th	29th	29.61	SSE	SSW	W	SSW., 10	
Wellfield, Br. M. S.	New Orleans	France	34 10 N.	62 26 W.	30th	5 a., 31st	31st	29.70	SSE	SSE., 8	S	SSE., 9	Steady.
Mediterranean Sea													
Silverlarch, Br. S. S.	Penang	New York	37 15 N.	4 30 E.	25th	4 p., 25th	26th	29.33	NW	WSW., 7	WNW	NW., 8	NW.-W.-WNW
Indian Ocean													
Clan Mackellar, Br. S. S.	Mauritius	Bunbury, Australia	27 30 S	89 22 E.	4th	4 p., 5th	5th	29.87	S	S., 8	SSE	S., 8	Steady S.
North Pacific Ocean													
West Niger, Am. S. S.	Japan	Astoria, Oreg.	43 03 N.	177 57 W.	Feb. 28	8 a., 28th	1st	28.90	SE	SE., 9	WSW	WSW., 10	SE.-SW.
Iyo Maru, Jap. S. S.	Victoria	Yokohama	51 12 N.	153 22 W.	Feb. 28	10 p., 2d	2d	28.61	S	SSW., 9	SW	SW., 10	S.-SE.-S.-SW.
Ayaha Maru, Jap. S. S.	Japan	Willapa, Wash.	48 28 N.	175 45 W.	3d	10 a., 4th	4th	28.40	S	S., 9	SSW	S., 11	
Havre Maru, Jap. S. S.	Otaru, Japan	San Francisco	47 50 N.	171 45 E.	3d	6 p., 3d	5th	28.54		SE., 8		SE., 11	SE.-SW.
Woyo Maru, Jap. S. S.	Karatsu, Japan.	Grays Harbor	39 43 N.	168 33 W.	4th	Noon, 8th	10th	28.86	SW	SW		SW., 10	W.-NW.
West Chopaka, Am. S. S.	Kobe, Japan	San Francisco	46 36 N.	169 52 E.	5th	6 p., 6th	6th	29.50	SSE	SSE., 11	S	SSE., 11	SSE., steady.
Pres. Garfield, Am. S. S.	San Francisco	Kobe	31 43 N.	142 31 E.	5th	Noon, 5th	6th	29.72	S	S. 9	NW	WNW., 10	S.-WNW.
Eldridge, Am. S. S.	Tsingtau, China.	Seattle	40 42 N.	153 30 E.	5th	11 p., 8th	8th	29.15	NNW	NE., 10	WNW	N. 12	E.-NW.
M. S. Dollar, Can. S. S.	San Francisco	Kobe	32 44 N.	149 55 E.	5th	7 p., 5th	8th	29.66	S	SSW., 8	NW	{SSW., 8. WNW., 8	
West Sequana, Am. S. S.	do	Yokohama	31 14 N.	174 30 W.	6th	2 a., 7th	7th	29.99	S	WNW., 8	N	WNW., 8	WNW., 10 pts.
Tokiwa Maru, Jap. S. S.	Yokohama	Victoria	48 12 N.	177 E.	7th	8 a.	7th	28.21	SE	SE., 4		—, 9	
Ayaha Maru, Jap. S. S.	Meike, Japan	Willapa, Wash.	48 56 N.	166 W.	6th	Midt., 6th	7th	29.71	S	S., 9	SSE	S., 9	
Capsa, Am. S. S.	Yokohama	San Francisco	42 N.	167 E.	8th	2 a., 9th	9th	28.78	ESE	W., 10	NW	W., 12	Steady W.
Oridono Maru, Jap. S. S	Nagasaki	Coos Bay	41 25 N.	166 45 E.	8th	11 p., 8th	10th	28.74	S	W	NW	W., 9	SW.-W.-WNW.
Arizona Maru, Jap. S. S.	Yokohoma	Victoria	41 22 N.	153 49 E.	11th	8 p., 13th	15th	28.91	WSW	NNE. ,9	W	NNW., 10	NE.-NW.
Eldridge, Am. S. S.	Tsingtau	Seattle	45 47 N.	164 47 E.	11th	11 p., 11th	12th	29.10	W	W., 10	SW	W., 12	Steady.
Tahchee, Br. S. S.	Manila	San Francisco	34 45 N.	150 E.	12th	5 p., 12th	13th	29.22	S	WSW	NNW	NNW., 10	WSW.-NW.
Pres. Madison, Am. S. S.	Seattle	Yokohama	45 07 N.	159 25 E.	14th	1 a.	14th	29.10	ENE	N., 7	NW	NNW., 10	ENE.-N.-NW.
Manoa, Am. S. S.	San Francisco	Honolulu	27 35 N.	148 W.	13th	3 p., 13th	15th	29.84	ESE	ESE., 6	SE	SE., 8	Steady.
Yokohama Maru, Jap. S. S.	Yokohama	Victoria	49 40 N.	169 W.	21st	4 a., 21st	22d	29.29	SSE	SSW., 8	SW	{SSW., 8. WSW., 8	
Java Arrow, Am. S. S.	Swatow, China	San Francisco	38 20 N.	157 32 E.	25th	11 p., 25th	26th	29.44	SSE	SSW., 7	WSW	S., 10	S.-SW.-W.
Meton, Am. S. S.	Cebu, P. I.	Portland	46 55 N.	174 33 E.	26th	2 p., 27th	27th	29.39	SE	S., 7	S	S., 10	
Akagisan Maru, Jap. S. S.	Yokohama	San Francisco	45 05 N.	166 56 E.	26th	7 a., 27th	27th	28.64	SE	SSW., 10	WSW	{S., 10. SSW., 10	}SE.-S.-SW.
Mauna Ala, Am. S. S.	Port Allen, T. H.	do	34 N.	134 W.	28th	4 a., 29th	29th	30.06	WNW	NW., 8	W	NW., 8	NW.-W.
Meton, Am. S. S.	Cebu	Portland	49 31 N.	169 W.	29th	Noon, 29th	30th	29.22	SSE	S., 10	W	SE., 11	SSE.-SSW.
Java Arrow, Am. S. S.	Swatow	San Francisco	38 11 N.	177 18 E.	29th	Midt., 29th	30th	29.89	S	SW., 8	NW	SW., 8	SW.-W.
Kongosan Maru, Jap. S. S.	Otaru, Japan.	do	45 N.	139 05 W.	29th	Noon, 29th	30th	29.81	NW	NW., 8	N	NW., 10	NW.-N.
Akagisan Maru, Jap. S. S.	Yokohama	do	47 21 N.	175 54 W.	29th	6 a., 29th	31st	28.87	SE	SW., 8	WNW	SE., 9	S.-WSW

NORTH PACIFIC OCEAN

By WILLIS EDWIN HURD

Following upon the abnormal pressure distribution over the eastern half of the North Pacific Ocean during February, March saw the anticyclone lying between the Hawaiian Islands and the California coast occupying its usual position practically throughout. In consequence, few cyclonic gales occurred in this region except along its boundaries. About the 13th low pressure developed near Hawaii, deflecting the trades for three or four days in this neighborhood and to the northward, and causing isolated moderate gales before it died out or passed into the Aleutian LOW on the 17th. During the last few days of the month a development of low pressure along the American coast disturbed the eastern area traversed by the California-Honolulu steamer routes, where it caused similar moderate gales along this periphery of the HIGH.

Owing largely to the great strength of the anticyclone, Honolulu experienced the windiest March on record. The average hourly velocity was 11.3 miles, and the highest velocity was at the rate of 36 miles an hour, from the east, on the 29th. Here, during the last twelve days of the month, especially strong east winds blew almost continuously in connection with the HIGH.

In the Aleutian region the center of low pressure lay nearly over or slightly to the westward of Dutch Harbor, and on several days during the first third of the month was sufficiently active to occasion storm to hurricane winds over an area roughly embraced between the 45th and 50th parallels, and from the 180th meridian eastward to longitude 165° W. The LOW had decreased greatly in activity during the last half of March. A secondary LOW occurred intermittently over the Gulf of Alaska, and from it cyclones entered the continent on the 1st, 4th, 7th, 14th, 19th, 21st, 23d, and 26th. Few gales were reported from this area, however, In fact, comparatively little stormy weather occurred east of the 160th meridian of west longitude. West of it, in addition to the area of violent storm already alluded to, the square roughly bounded by the 35th and 50th parallels, 150th and 170th meridians of east longitude, was the scene of an equally violent storm from the 8th to the 11th. The following report from the American tank steamer *Capsa*, Yokohama to San Francisco, T. N. McLeod, master, G. Watts, navigating officer and observer, will serve as an index to the roughness of the weather of this period:

March 8; 1925.—8 hours, ESE. 5, 29.74. Moderate westerly swell, overcast sky, sleet, visibility moderate. Noon, position by D. R., 42° 10′ N., 167° E. SSE. 9, 29.32. Moderate to heavy sea, overcast, moderate visibility. 13 hours, SE. 10, 29.20. Weather conditions indicating cyclone in vicinity. Reduced to half speed and hove to, starboard tack, heading ESE. 14 hours, SE. 11, 29.15. 15 hours, SE. 11, 29.10. 16 hours, SSW. 11, 29.00. Mountainous sea, very heavy rain with severe squalls. 17 hours, SW. 10, 29.00. Vessel heading SSE. 18 hours, SW. 8, 29.03. 19 hours, SW. 7, 29.00. 20 hours, SW. by W. 7 to 6, 28.97. Vessel hove to heading S. by E., labouring heavily to mountainous sea, violent rain squalls. 21 hours, WSW. 8, 28.98. Vessel heading S. by E. 22 hours, W. by S. 7, 29.00. Vessel heading south. 23 hours, W. 8, 28.98. Vessel heading south. Midnight. W. 8, 28.91. Vessel heading south, labouring and straining heavily to mountainous confused sea, violent squalls.

March 9.—1 hour, W. 8, 28.87. Hove to heading south, riding to mountainous sea; 1.20, engines eased to slow ahead. 2 hours, W. 9, 28.78. 3 hours, W. 10, 28.78. Vessel heading SW. 3.30 hours, W. 12. Very fierce squalls, with heavy rain and hail. Centre passed vessel's stern, traveling NE. by N. 3.45 hours, W. by N. 11. Barometer rising. 4 hours, WNW. 12, 29.03. Vessel hove to heading SW. by W., mountainous sea, fierce squalls. 5 hours, NW. by W. 11, 29.15. 6 hours, NW. 10, 29.40. 7 hours, NW. 9, 29.43. 8 hours, NW. 8, 29.50. Vessel hove to heading SW. by W., very heavy sea, cloudy sky, clear weather.

The various reports indicate more frequent and heavier snow squalls over the western half of the northern sailing routes than during any previous month of the season.

No information is at hand indicative of storms of a tropical nature in the Far East.

Along the western coast of Mexico and Central America conditions were quiet, no vessel reporting a single gale in these waters.

Except over the central Aleutians, pressure was practically normal at the island stations usually considered in connection with this meteorological element. At Dutch Harbor the average 8 p. m. pressure was 29.63 inches, or 0.11 inch less than the normal. The extremes were 30.42, on the 26th, and 28.56, on the 20th. To the eastward, at Kodiak, the average pressure was 29.76, or 0.01 inch above the normal. Here the extremes were 30.28, on the 11th, and 28.80, on the 3d. At Midway Island the 8 p. m. average was 30.09, or also plus 0.01 inch. The extremes were 30.34, on the 30th, and 29.82, on the 13th. A similar plus departure of 0.01 inch occurred at Honolulu, the average being 30.03, and the extremes, 30.17, on the 30th, and 29.75, on the 13th, these dates coinciding with those of similar data at Midway Island.

Fog was observed over nearly all parts of the ocean north of the 30th parallel, though most frequently east of the 170th meridian west. Here, especially between the 45th and 52d parallels, eastward to the 140th meridian, fog was entered by vessels on nearly every day from the 4th to the 20th. Along the American coast less fog was reported than in February—none from southern waters, and little north of San Francisco. Between San Francisco and the 30th parallel fog was noted by steamers on nine days.

DETAILS OF THE WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

ALFRED J. HENRY

March, 1925, like February, its immediate predecessor, was characterized by above-normal temperature in all parts of the country save the extreme southern tip of Florida. It was the second month of above-normal temperature in all parts of the country—a rare occurrence. The drought continued and was especially severe in the Gulf States and the Southwest.

A characteristic of both February and March, 1925, was the lack of intensity in the cyclones which gave character to those months. In March, 90 per cent of the cyclones decreased in energy with movement toward the Atlantic seaboard and a relatively large percentage did not reach the coast line. The usual details follow.

CYCLONES AND ANTICYCLONES

By W. P. DAY

The rapid fluctuations in pressure and temperature which characterized February continued in lessening degree during March. The number of LOWS charted was about the same as in January and February, but there was a falling off in the number of HIGHS. Two important storms affected interior districts, one which developed over the Southwest on the 12th and moved northeastward to Eastport, Me., by the night of the 14th, and another, originating over the Pacific, but of little importance until it had swung southeastward across the Rocky Mountains, which developed considerable intensity during the evening of the 18th as it passed over southern Illinois and southern Indiana. It was at this time that several very severe tornadoes occurred, their tracks paralleling that of the major disturbance. A typical Spring HIGH developed and spread southward over the Lake region between the 29th and the 1st of April.

FREE-AIR SUMMARY

By V. E. JAKL

It will be seen from Tables 1 and 2 that free-air conditions in March corresponded quite closely with the normal. This applies to the averages for all elements, for while there was a general excess in temperature at all stations for all levels, the departures were unimportant, being in no case more than two whole degrees above normal. The averages of relative humidity and vapor pressure for the upper air also show that while the month was drier than usual, the departures were unimportant.

As regards wind resultants for the month, there was some deviation from the normal in the lower levels, but on the whole, so far as averages are concerned, the month can be considered a normal one in that respect. These wind resultants are shown more comprehensively by the pilot-balloon observations, which give practically the same results as shown in Table 2 for kite observations, i. e., winds varying from southwest to northwest for the different stations in the lower levels, but becoming more westerly with altitude. At 4,000 meters altitude and above, winds from almost due west prevailed generally east of the Rocky Mountains.

While the averages show approximately normal winds, there was considerable variation from day to day, and at times marked differences in both velocity and direction between winds aloft and those near the ground. From the well-known relation between wind direction and temperature, these variations were naturally reflected in the records of temperature for individual days. Another feature of the month therefore, was the variability of temperature, not only as regards the temperatures themselves, but in the lapse rates with altitude. In addition to this variability, and probably resulting therefrom, there was frequent evidence in the records of unusual contrasts in temperature between adjoining regions.

A few examples from the records will serve to illustrate this variability in upper air temperature with time, distance, and altitude. On the 7th, the temperature at Drexel and Broken Arrow at 2,500 meters was almost identical, while in the first few hundred meters above the ground it was 18° C. warmer at the southern station; and again on the 12th, the temperature difference between these two stations changed in the opposite direction with altitude, the excess in temperature at Broken Arrow over that at Drexel increasing from 5° C. on the ground to 10° at 4,000 meters. At Royal Center the temperarose rapidly at all levels from the 2d to the 7th, the magnitude of the change being emphasized by the fact that on the 2d, the temperature from 500 to 1,500 meters was the lowest of record for the month, while on the 7th the temperature at 3,000 meters was the highest of record. On the 9th the temperature at Royal Center above 2,000 meters was still high, but in the lower levels had fallen, so that the temperature was about the same at 500 and 3,500 meters. Similarly, at Ellendale, a change is noted from low temperatures on the 1st—at some levels the lowest of record—to temperatures considerably above the normal on the 5th.

Considering differences in temperature between stations in a longitudinal direction, it is found on comparing Drexel and Royal Center, which are about 500 miles apart on an almost east-west line, that on the 2d it was considerably colder at Royal Center, especially in the higher levels, where, at 3,000 meters, it was 13° C. colder at Royal Center than at Drexel; while on the 10th the temperature at Drexel was lower than at Royal Center by an amount varying from 18° on the ground to 8° at 2,500 meters.

Means for the aerological stations show that the largest latitudinal contrasts in temperature at all levels occur in midwinter. It is, however, possible that in spring there are occasional inequalities in temperature, both latitudinally and longitudinally, and extending to a great depth, that approach those of winter in magnitude. So far as such contrasts in temperature are conducive to instability, those of spring are undoubtedly of more importance, owing to the greater moisture content of the air in spring than in winter. These means furthermore seem to show that in the higher levels there is in the spring months a temporary reduction in the rate of rise in temperature from midwinter to midsummer, from which it may inferred that at this time of year occasional strong lapse rates in temperature are likely to occur, when for any reason the temperature in the lower levels rises rapidly. These facts are of significance, in view of the fact that tornadoes are to a large extent peculiar to the spring months.

Free-air observations pertaining directly to the tornadoes of the 18th, will be discussed in the April REVIEW. The following extract from the report of the official in charge at Royal Center is of interest in connection with a severe thunderstorm that occurred at that station on the 10th, and which appeared to have some of the characteristics of a tornado:

> During the 2d flight a thunder squall of almost tornadic severity suddenly struck the station, causing considerable damage in this vicinity from broken windows, chimneys blown down, and outbuildings destroyed. In some cases there were evidences of a gyratory motion, as movable objects were found in places relative to their former positions, that indicated that their movement was backward instead of with the direction of progression of the disturbance. In some instances the windows were forced outwards, indicating that there must have been less pressure outside of the building than on the inside. This happened in the case of my own residence. Lightning struck the kite line at about 2:50 p. m., destroying 3,000 meters of wire and liberating 3 kites. The kites were recovered the next day about 6 miles northeast of the station.

This storm occurred along a typical wind-shift line in the southern portion of a LOW in which also, a strong temperature gradient extended from Saskatchewan southeastward to the Ohio Valley. The records show that the surface wind at Royal Center shifted abruptly from southwest to northwest at 2 p. m., continuing from the latter direction till the following day. The change in direction was accompanied by a rapid fall in temperature. Aloft, however, it is apparent from the records and the above account, that the wind remained about southwest to at least as low an altitude as 1,400 meters until past the time when the kites broke away at 2:50 p. m., the velocity being from 40 to 50 miles per hour. The surface northwesterly wind blew at the rate of 12 to 16 miles per hour, except at the height of the storm from 2:12 to 2:17 p. m., when a velocity of 54 miles per hour was recorded, with an extreme velocity of 70 miles per hour.

A condition somewhat related to the foregoing is that shown by the observation at Due West on the 31st, which was made at a time when a secondary depression, apparent on the p. m. map of that date on the Atlantic coast, was presumably forming in the vicinity of Due West. The observation was begun soon after the surface wind changed abruptly from west-southwest to northnortheast. The temperature above 3,000 meters was the lowest of record for March, while the temperature at and near the ground rose during the day until a dry adiabatic lapse rate extended to 3,900 meters. This is shown in the following table:

Altitude, M. S. L., meters	Time, P. M.	Temperature °C	Wind direction	Wind velocity	Time, P. M.	Temperature, °C.	Wind direction	Wind velocity
217 (surface)	4:21	17.8	nne	9	7:06	10.0	ne	8
1,000	4:38	7.9	n	12	6:56	3.0	nne	11
2,000	5:05	−1.5	nw	10	6:40	−5.6	n	18
3,000	5:35	−11.6	wnw	15	6:19	−12.4	nw	19
3,900	6:05	−17.7	wnw	23				

To the north cloudy weather and lower temperatures prevailed. A possible explanation of the formation of the secondary is therefore that a line of discontinuity in temperature formed between the cool cloudy weather to the north and the warm clear weather to the south, and that the high lapse rate in the region of Due West, by its instability, facilitated the intrusion of colder air in the lower levels from the north and northeast.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during March, 1925*

TEMPERATURE (°C.)

Altitude. M. S. L. m.	Broken Arrow, Okla. (233 m.) Mean	Departure from 7-year mean	Drexel, Nebr. (396 m.) Mean	Departure from 10-year mean	Due West, S. C. (217 m.) Mean	Departure from 5-year mean	Ellendale, N. Dak. (444 m.) Mean	Departure from 8-year mean	Groesbeck, Tex. (141 m.) Mean	Departure from 7-year mean	Royal Center, Ind. (225 m.) Mean	Departure from 7-year mean
Surface	12.2	+2.1	3.3	+0.1	11.6	−1.5	−0.5	+2.3	14.3	+0.9	5.4	+0.8
250	12.1	+2.1			11.4	−1.4			13.6	+0.8	5.1	+0.7
500	10.3	+2.1	3.0	+0.3	10.2	−0.8	−0.9	+2.0	12.8	+1.2	3.1	+0.7
750	9.3	+2.4	2.6	+0.9	8.8	−0.7	−2.1	+1.4	12.3	+1.6	2.3	+1.0
1,000	8.5	+2.4	2.9	+1.6	7.5	−0.7	−2.8	+1.0	11.6	+1.6	1.9	+1.3
1,250	7.8	+2.2	2.7	+1.5	6.4	−0.6	−3.3	+1.0	11.6	+2.2	1.0	+1.1
1,500	6.7	+1.8	2.3	+1.5	4.9	−0.8	−3.9	+0.9	11.4	+2.6	0.2	+1.1
2,000	4.5	+1.3	0.0	+1.0	2.2	−1.2	−5.9	+0.6	9.5	+2.2	−0.7	+1.6
2,500	1.7	+0.9	−2.6	+0.9	−0.9	−2.0	−8.5	+0.3	7.0	+1.8	−3.0	+1.5
3,000	−1.3	+0.6	−5.3	+0.8	−3.7	−2.6	−11.5	−0.1	4.8	+2.0	−5.5	+1.3
3,500	−4.4	+0.2	−8.0	+0.8	−5.9	−2.5	−14.4	−0.4	1.1	+1.0	−7.9	+1.1
4,000	−8.2	−0.4	−11.3	+0.1	−9.1	−2.8	−16.6	0.0			−11.6	−0.2
4,500			−14.0	+0.8	−12.1	−2.6	−17.8	+1.9				
5,000					−15.7	−2.6	−20.9	+2.1				

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during March, 1925*—Continued

RELATIVE HUMIDITY (%)

Altitude. M. S. L. m.	Broken Arrow, Okla. (233 m.) Mean	Departure from 7-yr. mean	Drexel, Nebr. (396 m.) Mean	Departure from 10-yr. mean	Due West, S. C. (217 m.) Mean	Departure from 5-yr. mean	Ellendale, N. Dak. (444 m.) Mean	Departure from 8-yr. mean	Groesbeck, Tex. (141 m.) Mean	Departure from 7-yr. mean	Royal Center, Ind. (225 m.) Mean	Departure from 7-yr. mean
Surface	53	−11	67	−1	58	−4	65	−10	63	−6	66	−5
250	53	−11			58	−4			63	−5	66	−5
500	53	−10	64	−3	55	−6	65	−9	64	−2	67	−3
750	50	−11	57	−8	53	−8	63	−6	58	−5	64	−3
1,000	47	−12	50	−11	50	−11	59	−6	53	−6	60	−4
1,250	42	−13	46	−10	47	−14	54	−7	45	−9	57	−4
1,500	40	−11	43	−9	46	−15	50	−8	38	−12	53	−6
2,000	37	−7	45	−6	45	−11	50	−6	35	−7	46	−10
2,500	36	−5	46	−5	45	−6	50	−6	36	−2	44	−11
3,000	35	−4	45	−7	39	−7	55	−2	30	−5	36	−18
3,500	29	−9	47	−5	34	−9	56	−1	29	−4	6	−45
4,000	30	−8	49	−2	36	−9	44	−11			6	−45
4,500			46	−8	36	−8	37	−18				
5,000					47	−2	37	−19				

VAPOR PRESSURE (mb.)

Altitude. M. S. L. m.	Broken Arrow Mean	Departure	Drexel Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure
Surface	7.67	−0.74	5.19	−0.09	8.15	−1.79	3.91	+0.04	11.12	−0.30	6.14	−0.25
250	7.61	−0.72			8.06	−1.72			10.75	−0.16	6.05	−0.22
500	6.74	−0.66	4.95	−0.05	7.23	−1.52	3.84	+0.08	10.35	+0.55	5.36	+0.01
750	6.01	−0.63	4.40	−0.06	6.37	−1.57	3.44	+0.16	9.06	+0.18	4.80	+0.04
1,000	5.38	−0.69	3.97	−0.03	5.52	−1.78	3.00	+0.03	7.84	+0.02	4.41	+0.13
1,250	4.61	−0.86	3.64	+0.06	4.72	−1.96	2.62	−0.10	6.39	−0.42	4.01	+0.12
1,500	4.15	−0.70	3.25	+0.03	4.02	−1.92	2.26	−0.25	5.16	−0.74	3.52	−0.05
2,000	3.11	−0.61	2.79	+0.07	3.08	−1.51	1.99	−0.16	4.06	−0.20	2.84	−0.17
2,500	2.46	−0.56	2.38	+0.06	2.29	−1.13	1.57	−0.21	3.61	+0.36	2.45	−0.12
3,000	1.90	−0.59	1.93	−0.03	1.48	−0.95	1.29	−0.13	2.27	−0.23	1.70	−0.50
3,500	1.14	−0.92	1.71	+0.09	0.91	−0.83	1.05	−0.10	1.37	−0.62		
4,000	0.68	−1.02	1.50	+0.11	0.84	−0.54	0.73	−0.17				
4,500			1.34	+0.09	0.74	−0.29	0.65	−0.05				
5,000					0.89	−0.16	0.61	+0.07				

TABLE 2.—*Free-air resultant winds (m. p. s.) during March, 1925*

Altitude M. S. L. m.	Broken Arrow, Okla. (233 meters) Mean		7-year mean		Drexel, Nebr. (396 meters) Mean		10-year mean		Due West, S. C. (217 meters) Mean		5-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 26° W.	3.4	S. 11° W.	2.1	S. 10° E.	1.1	S. 51° W.	0.6	N. 35° W.	1.3	S. 70° W.	1.8
250	S. 26° W.	3.4	S. 11° W.	2.2					N. 40° W.	1.3	S. 69° W.	2.0
500	S. 32° W.	5.0	S. 13° W.	3.6	S.	1.6	S. 49° W.	0.9	N. 44° W.	3.3	S. 74° W.	3.0
750	S. 40° W.	5.4	S. 17° W.	4.6	S. 44° W.	3.2	S. 77° W.	2.2	N. 51° W.	3.7	S. 75° W.	4.4
1,000	S. 51° W.	5.5	S. 30° W.	5.3	S. 62° W.	3.9	S. 84° W.	3.1	N. 54° W.	4.3	S. 74° W.	5.5
1,250	S. 71° W.	6.0	S. 43° W.	6.0	S. 74° W.	5.1	N. 86° W.	4.1	N. 59° W.	4.9	S. 74° W.	6.8
1,500	S. 79° W.	6.8	S. 59° W.	6.2	W.	5.7	N. 83° W.	5.1	N. 69° W.	5.7	S. 76° W.	8.7
2,000	N. 86° W.	7.8	S. 74° W.	7.1	N. 81° W.	6.4	N. 82° W.	6.8	N. 75° W.	7.2	S. 80° W.	10.8
2,500	N. 80° W.	10.8	S. 85° W.	8.4	N. 74° W.	9.9	N. 85° W.	8.7	N. 75° W.	8.5	S. 89° W.	12.1
3,000	N. 76° W.	10.7	N. 88° W.	9.6	N. 78° W.	12.0	N. 85° W.	11.2	S. 83° W.	12.9	S. 84° W.	13.7
3,500	S. 84° W.	11.8	S. 80° W.	10.7	N. 71° W.	14.2	N. 80° W.	14.7	N. 79° W.	13.4	S. 85° W.	13.9
4,000	N. 81° W.	10.9	S. 80° W.	9.8	N. 69° W.	19.4	N. 76° W.	17.8	N. 86° W.	16.2	S. 83° W.	15.4
4,500	S. 78° W.	15.8	S. 64° W.	11.0	N. 67° W.	18.6	N. 77° W.	17.5	S. 79° W.	15.8	S. 85° W.	16.4
5,000												

Altitude M. S. L. m.	Ellendale, N. Dak. (444 meters) Mean		8-year mean		Groesbeck, Tex. (141 meters) Mean		7-year mean		Royal Center, Ind. (225 meters) Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	N. 85° W.	2.3	N. 42° W.	2.1	S. 30° E.	1.2	S. 5° E.	1.1	S. 54° W.	1.9	S. 45° W.	1.7
250					S. 22° E.	2.1	S. 6° E.	1.9	S. 41° W.	2.0	S. 40° W.	1.8
500	N. 88° W.	2.7	N. 49° W.	2.0	S. 5° E.	3.2	S. 7° W.	3.5	S. 69° W.	5.7	S. 50° W.	4.5
750	W.	4.3	N. 73° W.	2.5	S. 10° W.	3.5	S. 19° W.	4.2	S. 76° W.	6.8	S. 57° W.	5.7
1,000	S. 89° W.	5.6	N. 80° W.	3.1	S. 31° W.	3.5	S. 33° W.	4.9	S. 88° W.	7.3	S. 65° W.	6.5
1,250	N. 87° W.	6.5	N. 75° W.	4.0	S. 38° W.	3.6	S. 41° W.	5.3	N. 84° W.	9.1	S. 73° W.	7.7
1,500	N. 85° W.	7.4	N. 78° W.	5.2	S. 47° W.	4.3	S. 48° W.	5.5	N. 70° W.	10.3	S. 79° W.	8.5
2,000	N. 83° W.	8.8	N. 77° W.	7.2	S. 58° W.	5.7	S. 60° W.	6.7	N. 72° W.	10.9	S. 83° W.	9.9
2,500	N. 87° W.	8.9	N. 76° W	9.5	S. 51° W.	7.5	S. 66° W.	8.8	N. 71° W.	12.8	S. 85° W.	11.0
3,000	N. 86° W.	10.5	N. 77° W.	11.0	S. 53° W.	11.9	S. 69° W.	9.7	N. 77° W.	16.6	S. 89° W.	13.8
3,500	N. 89° W.	9.2	N. 83° W.	12.6	S. 53° W.	15.3	S. 74° W.	12.8	N. 83° W.	19.1	S. 88° W.	16.4
4,000	N. 70° W.	16.9	N. 85° W.	15.0	S. 45° W.	19.0	S. 70° W.	14.4	S. 61° W.	24.7	S. 82° W.	15.6
4,500	N. 65° W.	15.8	N. 89° W.	15.2								
5,000	W.	17.0	N. 88° W.	17.3								

THE WEATHER ELEMENTS

By P. C. DAY, In Charge of Division

PRESSURE AND WINDS

Considering the month as a whole, and for the entire country, March, 1925, did not maintain its reputation as a month of marked variability in weather conditions, though locally it established records that will doubtless stand as landmarks for future reference. Chief among these is the great tornado that occurred in the early afternoon of the 18th, extending from a point in southeastern Missouri east-northeastward for a distance of over 200 miles across southern Illinois, and into southern Indiana. The loss of life and damage to property from this tornado were the greatest ever experienced in the United States from a single storm of this character. In addition to the main storm track there were several minor tornadoes in adjacent areas. The total loss of life from these storms was about 800, while property damage amounted to about $18,000,000. A full account of these storms will appear in the April number of the REVIEW.

Other important local features of the month were the unusual cold for March over the southeastern districts on the 2d and 3d, the intense heat over portions of the same districts at the beginning of the second decade, the wide-spread lack of the precipitation usually expected in March, and the continued severe drought over the southwest.

The cyclones and anticyclones moving across the country were not unusual as to extent, the cyclones giving as a rule only light to moderate precipitation, while the anticyclones were not attended by severe cold save that

advancing into the upper Missouri Valley at the beginning of the month. This reached the central valleys and Southeastern States on the 2d and 3d, accompanied at a few points by minimum temperatures as low as ever observed in March, and at others the temperatures were as low or even lower than had occurred during the previous winter months.

The average atmospheric pressure for the month was above normal over practically the whole United States and the eastern Canadian districts. It was slightly below normal over most of western Canada and small areas in North Dakota and Minnesota. As was the case in February, the highest pressure averages were over the southeastern districts, thus favoring the eastward passage of cyclones along a more northerly course than is usual for March, with frequent warm southerly winds, particularly over the Northeastern States and Great Plains region.

The principal high winds of the month were associated with the cyclone that moved from the middle Plains northeastward to Lake Superior on the 9th and 10th, and with that moving from the southern Plains northeastward to the lower lakes from the 17th to 19th, crossing the middle Mississippi Valley on the 18th, at which time the severe storms previously mentioned occurred. The important items concerning loss of life, damage to property, etc., associated with these and other storms that occurred during the month are given in the table below.

TEMPERATURE

The month as a whole was unusually warm and except for the first few days the daily changes were mainly unimportant, particularly during the latter half of the month.

The average temperatures were above normal, as was the case in February, over all portions of the United States and southern Canada, except for a few points along the Pacific coast from central California north to southern Washington. At numerous points the daily temperatures were normal or above almost continuously, and the monthly averages ranged generally from 4° to 6° above normal.

The principal warm periods were during the latter part of the first and the early part of the second decade, from the middle and southern Great Plains eastward to the Atlantic coast, at which time some of the highest temperatures ever observed in March occurred; about the end of the second decade over the far Southwest; and about the middle of the last decade over the more northern districts.

The lowest temperatures over the eastern half of the country were usually recorded on the 2d and 3d, at which time freezing weather occurred over the greater part of the Southeastern States and frosts occurred in the interior of northern Florida; though, on account of the short duration of freezing temperature, no important damage to vegetation resulted.

Temperatures below freezing occurred in all the States and they were as much as 20° to 30° below zero in the northern border States and at some of the high altitudes of the western mountains.

PRECIPITATION

A marked deficiency in the precipitation existed over much of the country and the averages by States were below normal in all but New England, New York, and Montana, where small excesses occurred.

The month was remarkably dry in the southern districts, particularly in the cotton-growing sections, where, at many points, precipitation was the least reported in March for 50 years or more. In portions of the west Gulf coast sections rainfall has been deficient since the beginning of the year.

Severe drought existed at the end of the month from Texas westward. In New Mexico it has continued for a year or more, and in portions of Arizona the water supply is the lowest ever known.

In southern California, where severe drought had existed, there was very general relief during the last few days of the month, when practically the entire State had beneficial rains or snows.

SNOWFALL

Appreciable snow occurred during the month over all central and northern districts, but the amounts were nearly everywhere less than usually fall in March.

In the districts east of the Rocky Mountains there were falls totaling from 5 to 20 inches or more in the northern portions of New England and New York, and generally from 5 to 10 inches in the Great Lakes region. Over the States from Minnesota to Montana there was considerable snow in the northern portions, particularly on the 9th and 10th.

In the western mountain regions important additions to the amounts of snow on ground at the end of February occurred in parts of California, particularly on the western slopes of the southern Sierra, as much as 100 inches being recorded locally. Generally speaking, the amount of snow on the ground over the western slopes of the Sierra at the end of March was greater than at the same time last year, though it was still materially below the normal over important districts. Over the eastern slopes of the Sierra there was a decided deficiency in the March snowfall, and the amount on the ground at the end of the month was less than at the same time last year.

Over other mountain sections the snowfall was nearly everywhere less than usually received in March, the fall being decidedly light in Utah, Arizona, New Mexico, and in the Pacific Northwest.

The outlook for the late supply of water in the main irrigation districts is generally unsatisfactory, particularly in the southern mountains, though the outlook in the drainage area of the Roosevelt Dam in Arizona is reported as good.

At the close of the month the snow had disappeared from all parts of the country save extreme northern New England, locally in the Adirondack Mountains of New York, at a few points in the upper Lake region, and at the higher elevations in the western mountains.

RELATIVE HUMIDITY

Conforming to the rainfall conditions, the relative humidity was below normal in all parts of the country except over the northeast, and locally in a few other sections. Deficiencies were large over most of the Southern States and from the Mississippi River westward, save along the middle and north Pacific coast, where a few places had percentages only slightly less or even slightly more than the average.

SUNSHINE AND CLOUDINESS

Due to the absence of important rainy periods in the southern districts there was an unusual amount of sunshine for March over those districts, and this condition existed over much of the Plains and Mountain regions of the West. In the far Northwest there was about the usual amount of cloudy weather, and similar conditions existed in the Great Lakes region.

SEVERE LOCAL HAIL AND WIND STORMS, MARCH, 1925

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
New York, N. Y., and vicinity.	1					Wind and rain	Considerable damage along the coast.	Official, U. S. Weather Bureau.
Lincoln to Miami Counties, Ind.	10	1:45 p. m.	1,760-2,640			Wind	Roofs, wires, and barns considerably damaged.	Do.
Leflore County, Okla. (NE. part of).	10	2 p. m.	1,760-6,160		$15,000	Severe hail	At Poteau many roofs badly riddled, auto tops damaged, gardens and fruit trees injured; some damage at Brazil.	Do.
Bloomer, Ark	10	P. m.				do	Amount of damage not reported.	Do.
Lafayette, Ind	10	3 p. m.			$1,000	Wind	Buildings damaged.	Do.
Cass, Fulton, and Kosciusko Counties, Ind.	10	2-3:30 p. m.	220-5,280		$75,000-100,000	do	Extensive property damage; trees blown down.	Do.
McKeen, Ill., to St. Mary-of-the-Woods, Ind.	10	3 p. m.	220-440		$100,000	Tornado and hail.	Numerous buildings demolished, others damaged; trees uprooted, poles blown down; car service disrupted. Path 10 miles long. Three persons injured.	Do. The Star (Terre Haute, Ind.)
Indianapolis, Ind	10	4:08-6:15 p. m.				Thunderstorm	Some damage to residences and power systems.	Official, U. S. Weather Bureau.
Cleveland, Ohio	10	6:55 p. m.				High wind	Radio tower blown down; trees, poles, and wires broken.	News (Cleveland, Ohio), Plain Dealer (Cleveland, Ohio).
Beaver, Kans	11	11:30 p. m.				Heavy hail	Amount and character of damage not reported.	Official, U. S. Weather Bureau.
Koolau, Kauai, T. H., extending into Kilauea and Moloaa.	12	1:30-6 p. m.	3,520			Hail and wind	Damage by shredding the leaves of cane and breakage by wind.	Do.
Bernice, La. (3 miles northeast of).	13	P. m.				Probably tornado and rain.	Four dwellings and numerous outbuildings wrecked.	Times (Shreveport, La.).
Winfield, Kans., and vicinity.	18	3 a. m.	5,280			Heavy hail	Much glass damaged in city; considerable crop damage.	Official, U. S. Weather Bureau.
Montgomery County, Kans. (southern part of).	18	5 a. m.	5,280			Probably tornado, with heavy hail.	Many rural homes damaged; telegraph and telephone service paralyzed. Heaviest damage in Deering, Caney, and Havana.	Do.
Reynolds County, Mo., to Pike County, Ind.	18	12:55-4:30 p. m.	440-1,760	742	$16,500,000	Tornado	The most disastrous tornado on record. At least four-fifths of damage and deaths were in Illinois; Murphysboro suffered most. Path 214 miles long. Description will be found in April Review.	Do.
Harrison County, Ind., to Oldham County, Ky.	18	5:15-6:10 p. m.	17-880	6	$200,000	do	Heavy property damage; 95 persons injured. Path 40 miles long.	Do.
Marion County to Bourbon County, Ky.	18	6-7:30 p. m.	200-400	2	$850,000	do	Destruction in path almost complete; 40 persons injured. Path 65 miles.	Do.
Sumner County, Tenn., to Adair County, Ky.	18	5 p. m.	167-880	38	$200,000	do	Extensive property damage; more than 30 dwellings wrecked in Tennessee; many persons injured. Path 65 miles long.	Do.
Williamson and Rutherford Counties, Tenn.	18	5:45 p. m.	100-400	1	$30,000	do	Six or eight buildings blown down and other property damage; heaviest loss at Kirkland; 9 persons injured. Path 20 miles long.	Do.
Bedford and Rutherford Counties, Tenn.	18	6 p. m.	100-200	2	$20,000	do	Eight or ten buildings completely demolished and as many more partially damaged; much destruction of timber.	Do.
Littleville, Ala.	18	4:45 p. m.	60	1	$15,000	Probably tornado and rain.	Twelve persons injured; 4 homes and a number of other buildings destroyed. Path about 12 miles long.	Do. Star (Anniston, Ala.).
Anniston, Ala	18	P. m.			$2,500	Severe thunderstorm.	Several structures demolished, roofs of others damaged. Wires and poles down in the vicinity.	Do.
Putnam, Knox, and Bedford Counties, Tenn.	18	P. m.		3		Wind and electrical.	Amount of damage not reported; 2 deaths were due to live wires and 1 to lightning.	Official, U. S. Weather Bureau.
Chapel Hill, Tenn	18	6-7 p. m.	3,520		$5,000	Heavy hail	Roofs and windows damaged.	Do.
Chattanooga, Tenn	18	6:40-9:50 p. m.			$5,000	Thunderstorm	Roof torn from Watkin's Hosiery Plant and negro shack damaged; telephone service impaired.	Do.
Paducah and Owensboro, Ky.	18	P. m.				High wind	Amount of property damaged unestimated.	Do.
Vanderburg County, Ind	18					Hail	Amount of damage not reported.	Do.
Bee Branch, Ark. (near)	18					Electrical	Barn and feed destroyed; 3 head of stock killed.	Do.
Southern and central Michigan.	18-19					Wind, rain, and snow.	Many poles broken; wire communication interrupted; traffic blocked.	Do.
Northern Mississippi	18-19					Hail	No extreme damage reported.	Do.
Laurens, S. C. (near)	19	2 a. m.				Thunderstorm	Damage not reported.	Do.
Scranton, Pa	19	A. m.				High wind	Considerable damage throughout city.	Scranton Republican (Pa.).
Western and northwestern New York.	19	A. m.				High winds	Several houses demolished, many damaged; trees and wires broken; other minor damage.	Star Gazette (Binghamton, N. Y.), News (Buffalo, N. Y.).
Holmes County, Fla. (W. part of).	19	2 p. m.				Heavy hail	Considerable destruction; all gardens a total loss; fruit trees injured.	Official, U. S. Weather Bureau.
Downing and St. Catharine, Mo.	20					Wind	Two buildings damaged.	Do.
Goodman Heights, Kans.	20	P. m.		1		Violent wind	Small buildings demolished	Do.
Center Village, N. Y.	21	A. m.				Probably tornado.	Roofs torn off; barns and sheds demolished; 2 cows killed.	Morning Sun (Binghamton, N. Y.).
Cushing, Okla.	31	7:30 a. m.				Heavy hail	No estimate of damage obtained.	Official, U. S. Weather Bureau.
Montmorenci, S. C.	31	6:30 p. m.				Severe thunderstorm.	Amount of damage unknown.	Do.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

The weather of the month taken as a whole was rather active, being characterized by numerous developments particularly along the middle Atlantic coast.

Advices were issued the morning of the 1st for strong east winds on the Atlantic coast from Delaware Breakwater to Eastport, in connection with a secondary disturbance of increasing intensity over the south Atlantic coast.

At 1:25 p. m. on the 5th when a disturbance of moderate intensity was over eastern North Carolina, warnings were disseminated for increasing easterly winds with overcast weather and rain from Delaware Breakwater to Portland, Me. On the following morning advices were issued for strong winds and gales off the coast from Hatteras to Eastport. Strong winds occurred on the coast from Cape Henry to Hatteras and probably off the middle and north Atlantic coast, although vessel reports are not available to verify this.

When a disturbance was over Hudson Bay on the evening of the 10th, warnings were issued for strong southwest winds on the following day from Sandy Hook to Portland. No verifying velocities were reported but fresh to strong winds occurred.

With a disturbance over the middle Mississippi Valley on the afternoon of the 13th moving rapidly east-northeastward, advisory warnings were ordered for the Atlantic coast from Sandy Hook to Eastport for increasing east winds becoming strong late that night or the following day. This was supplemented on the following morning by the dissemination of southwest storm warnings from Delaware Breakwater to Eastport and on the afternoon of that date warnings were extended southward to Southport, N. C. Strong winds occurred as indicted.

On the morning of the 17th a disturbance of slight but increasing intensity was over North Carolina and moving northeastward, and advices were issued for increasing east winds, Delaware Breakwater to Boston. While this disturbance did not cause strong winds on the immediate coast, vessel reports indicate that strong winds occurred some distance off the coast.

The evening radio bulletin for the north Atlantic coast, issued on Wednesday the 18th, indicated "Increasing southeast shifting to south and southwest winds, becoming strong Thursday night." The disturbance that was over Indiana moved rapidly northeastward by the morning of the 19th, and winds had increased along the northern New Jersey and the Long Island coasts. Storm warnings were immediately ordered from Hatteras to Eastport for strong southwest shifting to west winds with squalls, and strong winds occurred during the day. The warnings were lowered at 10 p. m. of the 19th.

On the morning of the 27th, when a disturbance was over Hudson Bay with a trough extending southward to Georgia, advisory warnings were disseminated for the Atlantic coast from Hatteras to Eastport for fresh south and southwest winds shifting to northwest with squalls. During the afternoon special observations indicated that the disturbance was increasing in intensity and northwest storm warnings were ordered displayed from Cape Hatteras to Provincetown, Mass. The evening of that date southeast warnings were ordered north of Provincetown to Eastport, Me. Strong winds and gales occurred substantially as indicated in the warnings.

With a disturbance off Nantucket on the morning of the 31st apparently increasing in intensity and moving northward, warnings were ordered from Sandy Hook to Eastport. While the disturbance increased in intensity and moved northward as anticipated, winds did not reach dangerous velocities, as shown by the coast stations.

On the afternoon of the 31st a disturbance of small diameter developed over the South Atlantic States, being central on the evening of that day over eastern Georgia and storm warnings were ordered from Norfolk to Charleston. Winds were strong along the South Carolina coast during the night, but having diminished by the following morning the warnings were ordered down.

Frost warnings were issued for portions of the east Gulf and South Atlantic States on the 1st, 2d, 5th, 6th, 15th, 19th, 27th, 28th, and 30th; and for the Ohio Valley and Tennessee on the 27th, 28th, and 30th. On the 16th and 29th cloudiness prevented the occurrence of frost in portions of the States indicated in the warnings.—*R. H. Weightman.*

CHICAGO FORECAST DISTRICT

The monthly mean temperature was considerably above the seasonal normal over the entire forecast district; and, while a cold wave was quite general during the first few days of the month, mild weather was almost the rule thereafter, there being few lapses to lower temperature. Cold-wave warnings were issued on the 1st for the areas affected, but other cold-wave warnings during the month were for quite limited localities.

Storms on Lake Michigan.—Rather strong winds prevailed on Lake Michigan on a few occasions, and advisory messages were sent to open ports where navigation was maintained.

Frost warnings.—No warnings of frost were issued, except for Kansas, where service was begun on the 18th, and to the strawberry growers of southwestern Missouri, warnings being sent to the latter on March 18, 19, and 26.

The most prominent meteorological features of the month were the destructive tornadoes which occurred in the extreme southern portions of Indiana and Illinois and southeastern Missouri on the 18th. Rains and strong shifting winds were predicted for this area, but following the practice of the Bureau, no forecast for tornadoes was made.

Special forecasts were continued each Monday to certain fruit exchanges in the State of Washington covering the area over the Middle States for the protection of apples in transit, and these advices were discontinued for the season on March 23. The following letter was received from the Northwestern Fruit Exchange, Wenatchee, Wash.:

> We wish to take this opportunity of thanking you most sincerely for the service you have given us during this shipping season.
>
> We are endeavoring in every way possible to handle the transportation of our Northwestern apples with the least possible loss. The service that you have given us has enabled us in a great many instances to prevent loss by placing shipments under the proper protective service.

Other special forecasts and warnings were issued at different times to various interests in the district, covering the shipment of perishable goods.—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT

Moderate weather conditions prevailed over this district during the month. Cold-wave warnings were issued on the morning of the 13th for Oklahoma, extended at night over the northwest portion of East Texas and were extended on the morning of the 14th over Arkansas, the

remainder of East Texas, and northern and western Louisiana. The warning was only partially verified. Frosts occurred on a few dates for which warnings were issued.

Northwest storm warnings were issued for the eastern portion of the Texas coast, and small-craft warnings for the western part on the morning of the 14th, and verifying velocities occurred within the period of the display. No general storm occurred without warnings.—*I. M. Cline.*

DENVER FORECAST DISTRICT

Disturbances that had developed on the Plateau, or had advanced from that portion of the Pacific coast immediately to the northwest, were present in the southern portion of the Rocky Mountain region during most of the time from the 5th to the 13th and from the 26th to the end of the month. These LOWS were attended, at some time during their passage eastward, by snow or rain in nearly all parts of the district except southeastern New Mexico, although the precipitation east of the Continental Divide was everywhere extremely light. On the 16th–17th a disturbance advanced southward along the eastern Rocky Mountain slope to northern Texas, where it recurved to the northeastward. It was attended by light snow in Colorado on the 17th and by violent and highly destructive local storms in southern Illinois when it crossed that region on the following day.

Warnings of moderate cold waves in eastern Colorado were issued on the mornings of the 10th, 13th, and 17th. The first of these was partially, and the last two were fully verified.

Warnings of freezing temperatures and frosts which were generally verified were issued as follows: Freezing temperature in southern New Mexico and southeastern Arizona on the 11th and 13th, and in extreme southeastern New Mexico on the 14th, 15th, 18th, and 19th. Warnings of frosts in southwestern Arizona on the 11th and 13th; in south-central New Mexico on the 14th, 15th, 18th, and 19th; in southern New Mexico on the 16th, and in the western valleys of Colorado on the 31st.

Owing to the extreme dryness on the eastern slope of the Rockies in Colorado, where some fires had already started, a fire-weather warning of strong shifting winds during the following day was issued for this portion of the State on the evening of the 31st, when a disturbance was advancing northeastward from Utah. The warning was fully justified.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT

As a rule the month of March was a relatively quiet one in the Pacific States Forecast District. Storm warnings were ordered on but two days, the 14th and 30th, for the north coast; on one day, the 29th, for the coast south of San Francisco; and on one day, the 30th for the San Francisco Bay region. Frost warnings were ordered for parts of California daily from the 6th to 13th and for Washington and Oregon for the 6th, 7th, and 8th, and the 23d, 25th, 28th, and 29th. These forecasts were verified in practically all instances, but the extent of damage from frosts is not definitely known. The early issue of frost warnings in Washington and Oregon was necessary because the growing season was considerably ahead of normal.

Considered from the standpoint of forecasting, the month was an interesting one, especially for California, where except for two periods, namely the 7th to the 10th and the 26th to the 31st, inclusive, when rain fell in nearly all parts of the State, fair weather was general. The rainfall was heavy and general during the period beginning the 26th and continuing into the month of April. The occurrence of these rains was more than likely due to the abnormal developments and displacements of the area of high barometric pressure that normally is found off the California coast. In the former instance of rains in California, i. e., the 7th to 10th, this area of high barometric pressure was far north of its normal position, and its major axis paralleled the meridians, whereas usually its major axis lies more or less east to west, and with its eastern periphery impinging on the coast. In this instance, an area of low barometric pressure formed over Nevada and caused light to moderate, though general, rains in California. Beginning on the 26th, however, there was a radical departure from the normal pressure situation over the ocean. The area of high barometric pressure, normally central near latitude 32° and longitude (west) 140°, retreated westward approximately 20° in longitude, and permitted LOWS from the north Pacific to advance southeastward and bring California under their influence. The result was that a series of LOWS, the like of which had not occurred previously for a long time, crossed the coast line south of the Oregon border, and caused general and heavy rains throughout California. Occurrences such as this indicate that a knowledge of the behavior of this area of high barometric pressure is essential to determining the times of those changes from the usual fair-weather types of isobaric patterns which bring on periods of unsettled weather and rains in California.—*E. H. Bowie.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD, in Charge of Division

With but two exceptions the floods of March in the larger rivers were very moderate, and all, aside from an ice-gorge flood in the Missouri River near Niobrara, Nebr., occurred east of the Mississippi River. The usual statistical data will be found in the table at the end of this report.

The most severe flood of the month occurred in the Connecticut River and its tributaries. Moderately heavy rains fell on March 28 and 29 but the temperatures had been high for several days, and there was a snow cover over the upper drainage basin ranging in depth from 7 to more than 20 inches, probably equivalent to at least 2 inches of water, so that with the rainfall there must have been approximately 3 inches of water, a sufficient quantity to have caused a severe flood at this time of the year regardless of other conditions. Reports, official and otherwise, indicate that disastrous floods occurred throughout New Hampshire and Vermont and in the smaller streams of the Adirondack region of New York. In the lower Connecticut River Valley the flood crest was not an unusual one for the time of the year and virtually no damage resulted. In the upper valley the damage was quite severe but it was impossible to obtain any estimates as to the amount thereof. The town of Randolph, Vt., suffered severely, two dams and 6 houses having been swept away, with resulting damage amounting to about $50,000.

In connection with the Connecticut River it is interesting to note that all records for continuous navigation of the lower river have been surpassed, the river having been open without intermission since March 24, 1923.

The second flood of importance was that of the Wabash River of Indiana and Illinois. It was caused by the heavy rains of March 13 and 14 over the Wabash drainage basin. At Lafayette, Ind., the crest stage of 22 feet on March 15, was 11 feet above the flood stage, while below Lafayette the crests averaged from 4 to 5 feet above the flood stages.

As there were no growing crops in the lowlands the losses were small, probably as much as $20,000, mostly through enforced suspension of certain business activities in the urban districts. The reported value of the property saved through the Weather Bureau warnings was $30,000.

An ice gorge about 5 miles in length and 20 feet in height formed between March 3 and 5 in the Missouri River from the mouth of the Niobrara River westward. Bottom lands in some places were under 12 feet of water, but fortunately the ice gave away in about 36 hours and the river gradually receded. Warnings were issued promptly upon receipt of the first advices and the reported losses were only $2,500, while the saving of property by reason of the warnings was estimated at $8,000.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE					
Connecticut:	*Feet*			*Feet*	
White River Junction, Vt	15	28	(2)	22.5	29
Bellows Falls, Vt	12	30	30	13.4	30
Holyoke, Mass	9	31	(2)	9.4	31
Hartford, Conn	16	30	(2)	20.5	31
Unadilla, New Berlin, N. Y	8	15	15	8.2	15
Santee:					
Rimini, S. C	12	20	23	12.8	22
Ferguson, S. C	12	1	1	12.0	1
		21	25	12.3	23, 24
EAST GULF DRAINAGE					
Cahaba, Centerville, Ala	25	18	18	25.0	18
Tombigbee, Lock No. 4, Demopolis, Ala	39	19	27	47.0	24
Pearl, Jackson, Miss	20	21	30	25.5	25
GREAT LAKES DRAINAGE					
Maumee:					
Fort Wayne, Ind	15	14	20	19.7	15
Napoleon, Ohio	10	16	16	10.0	16
St. Joseph, Montpelier, Ohio	10	15	16	11.5	15
		20	21	11.9	20
Auglaize, Defiance, Ohio	10	16	16	10.9	16
MISSISSIPPI DRAINAGE					
Tuscarawas, Gnadenhutten, Ohio	9	20	20	9.4	20
Scioto, LaRue, Ohio	11	15	15	11.0	15
Green, Lock No. 2, Rumsey, Ky	34	(1)	3	36.6	1
Wabash:					
Lafayette, Ind	11	14	22	22.0	15
Terre Haute, Ind	16	15	25	20.9	19
Vincennes, Ind	14	19	29	19.5	22, 23
Mount Carmel, Ill	16	19	28	20.5	23, 24
White, West Fork:					
Elliston, Ind	19	16	18	20.9	18
Edwardsport, Ind	14	17	21	17.3	19
Illinois:					
Peru, Ill	14	(1)	6	15.3	Feb. 25
		18	31	15.8	Mar. 23
Henry, Ill	7	(1)	(2)	9.6	24, 25, 26
Peoria, Ill	16	23	31	16.4	25, 26
Havana, Ill	14	24	(2)	14.3	27–30
Beardstown, Ill	12	(1)	(2)	15.4	28, 29
Cache, Patterson, Ark	9	2	6	9.9	4

[1] Continued from last month.
[2] Continued at end of month.

MEAN LAKE LEVELS DURING MARCH, 1925

By UNITED STATES LAKE SURVEY

[Detroit, Mich., Apr. 7, 1925]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during March, 1925:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	600.80	578.38	570.91	245.20
Above or below—				
Mean stage of February, 1925	−0.16	+0.14	+0.42	+0.79
Mean stage of March, 1924	−0.26	−0.31	−0.31	+0.32
Average stage for March last 10 years	−0.85	−1.46	−0.71	−0.21
Highest recorded March stage	−1.52	−4.57	−2.94	−2.61
Lowest recorded March stage	+0.14	−0.31	+0.08	+0.90
Average relation of the March level to—				
February level		+0.1	+0.2	+0.2
April level		−0.3	−0.6	−0.6

[1] Lake St. Clair's level: In March, 1925, 573.41 feet.

FLOOD PROTECTION IN WICHITA, KANS.

By S. P. PETERSON

[Weather Bureau, Wichita, Kans.]

The city of Wichita is situated at the confluence of the Big Arkansas and the Little Arkansas Rivers, the Big Arkansas River passing through the southwestern part of the city with a southeasterly trend and the Little Arkansas flowing in a very winding course southward through the northwestern part of the city and emptying into the Big Arkansas River a short distance to the northwest of the central business section. To the east of these two rivers lies about two-thirds of the city, and this part is bisected by Chisholm creek and its continuation, the drainage canal, which flows in a general southward direction through it, emptying into the Big Arkansas River a short distance below the city.

The site of the city of Wichita has been subjected to three extensive floods, one in 1877, one in 1904, and the last in 1923. There have also been several minor floods. In extensive flooding the overflow waters of the three streams tend to merge and form a shallow lake, covering much of the city and surrounding territory.

Immediately after the flood of 1904 action was taken to control the flood waters, especially of the Little Arkansas River and Chisholm Creek (then flowing in its natural winding course southward through the eastern portion of the city) as these two streams caused the most damaging overflows. This control was accomplished to a certain extent by constructing dykes along the portion of the Little Arkansas River from which the overflow waters moved toward the central business section and by clearing the channel of that portion of the stream of such obstructions as would hinder the streamflow, while through the section drained by Chisholm Creek, a canal (the present drainage canal) was dug from the Stock Yards district, near the extreme northern portion of the city to the mouth of the stream, eliminating the windings of this stream within most of the city, making a straight course for the streamflow and also a considerably larger channel capacity than

the original creek. The streamflow capacity of the Big Arkansas River was increased mainly by the pumping of sand from the bed of that stream, thus lowering the river bed, the pumping being done by private companies for the commercial value of the sand. While this was not a part of the flood-protection scheme, yet it was none the less effective. The river bed was lowered in places about 7 feet.

The flood of 1923 found the city prepared to the extent indicated, with the result that the main business section entirely escaped overflow, though the residence sections along the middle and upper course of the Little Arkansas River were extensively overflowed. The section in the Chisholm Creek drainage was overflowed as extensively as in 1904, but the straight-away lead and the larger carrying capacity of the drainage canal through that section caused the flood waters to recede quickly. The Big Arkansas River did not overflow within the city except in limited places in the extreme southern portion of the city.

The carrying capacity of the drainage canal at the time of the 1923 flood was 2,500 second-feet, though this was considerably restricted by the low arches of the bridges that spanned it. The estimated flow of the 1923 flood through that section was about 6,500 second-feet.

The carrying capacity of the Little Arkansas River at the time of the 1923 flood was 10,000 second-feet, but the estimated flow of that flood in the lower section of this stream was about 12,500 second-feet.

The carrying capacity of the Big Arkansas River, within the city of Wichita, was not reached in the 1923 flood, except in limited areas, as indicated, and the flow passing through it was estimated at 17,000 to 18,000 second-feet below its confluence with the Little Arkansas River.

The general slope of the land downstream in this section is about 5 feet to the mile.

The present plan of flood protection contemplates widening and deepening the drainage canal to a capacity flow of 8,000 second-feet, widening and diking the Little Arkansas River to a capacity flow of 12,500 second-feet throughout its entire course within the city, and widening certain obstructed sections of the Big Arkansas River, increasing its capacity to 20,000 second-feet, with a 3-foot freeboard for each stream as a further margin of safety. This work is now fairly under way, and it is expected that it will be completed early in 1926. The entire cost of this project will be about $800,000.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, MARCH, 1925

By J. B. KINCER

General summary.—The mild, dry weather during much of March made conditions unusually favorable for farm operations in nearly all sections of the country, and both vegetation and farm work were considerably ahead of an average season. Two cool spells temporarily checked growth, especially the unseasonably low temperatures in the Southeast near the beginning of the month, and some local damage was done by frost. In general, however, the harm from low temperatures was not extensive and vegetation made good progress. Much plowing was accomplished in the interior valleys, while spring planting advanced rapidly in the South, except in the dry Southwest where the moisture situation was largely unrelieved at the close of the month. Good rains were beneficial during the first half over the interior States and in southeastern districts showers were helpful during the latter part of the month.

Small grains.—Winter wheat and other fall-seeded grains made satisfactory progress in the principal producing areas, except in portions of the western and southwestern Winter Wheat Belt where it was too dry. Moisture was especially lacking in Texas, most of Oklahoma, and parts of Kansas and Nebraska. It was generally favorable for cereal crops in the Atlantic and east Gulf States and also in the far Northwest, but it was too dry in west Gulf districts.

Spring wheat seeding advanced rapidly the latter part of the month, under favorable weather conditions, and was completed in some southern sections of the belt. Oat seeding also advanced favorably, especially in the upper Mississippi Valley and northern Great Plains, with the early-seeded germinating well in the central valley States.

Corn and cotton.—Considerable corn ground was prepared in the interior valleys, with favorable soil condition, and at the close of the month planting had advanced northward to extreme southern Kansas, Tennessee, and North Carolina. Planting was retarded, however, in Texas and Oklahoma, and the soil was too dry in those States for proper germination. In the Southeast conditions were generally favorable for germination and corn had come up to a good stand.

The preparation for cotton planting made good progress, and seeding had become general in Gulf coast sections. Some cotton was planted as far north as southern North Carolina and the central portion of Arkansas. In Texas seeding made slow advance and conditions were unfavorable for growth of early cotton, except in the extreme South and the northeast.

Ranges, pastures, and livestock.—The weather was generally favorable for grazing interests in central and northern sections of the western grazing country, but it was mostly unfavorable in the South because of deficient moisture. Rainfall was sufficient during the latter part of the month to improve the range in eastern Oklahoma, parts of northern Texas, Arizona, and southern California, but elsewhere in the Southwest there was little relief from the drought and the range outlook was poor. In the eastern half of the country meadows and grass lands were in satisfactory condition generally.

Fruit.—Influenced by the persistent mild temperatures, early fruit continued to advance prematurely in the central portions of the country, though buds remained dormant in much of the upper Ohio Valley. There was some frost damage in parts of the South and the far West, but on the whole this was not extensive. Early fruits were setting well in Southern States, and reports on citrus were favorable. Strawberries were being marketed at the close of the month in the extreme lower Mississippi Valley, and shipments were active in northern Florida.

Miscellaneous crops.—Early gardens and truck crops were being planted in the Middle Atlantic and central valley States, while in the Southeast growth was generally favorable. Truck was thriving in California, but it was too dry in the west Gulf area.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, March, 1925

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	58.4	+1.7	Troy	90	12	Valley Head	13	2	2.70	−2.59	Birmingham	5.47	Spring Hill	0.22
Alaska (*February*)	9.9	−5.3	Hydaburg	53	27	Allakaket	−62	2	2.56	−1.43	Dutch Harbor	10.04	Anchorage	0.10
Arizona	54.7	+2.7	Buckeye	97	20	Ryan Ranger Station.	2	[2] 13	0.74	−0.34	Young	4.75	7 stations	0.00
Arkansas	55.9	+3.3	2 stations	89	[2] 25	Eureka Springs	7	2	1.69	−3.01	Portland	5.68	Morrillton	0.04
California	52.8	+1.3	Greenland Ranch	97	21	Helm Creek	−19	11	2.67	−1.13	Lake Eleanor	6.79	Greenland Ranch	0.00
Colorado	37.6	+3.2	2 stations	86	[2] 6	2 stations	−16	[2] 1	1.07	−0.33	Cumbres	7.61	3 stations	0.00
Florida	66.0	+0.3	Orlando	93	9	Garniers (near)	25	3	1.91	−0.96	Jupiter	8.88	Temple Terraces	0.14
Georgia	58.2	+1.4	3 stations	91	[2] 10	Clayton	9	3	2.05	−2.84	Clayton	6.03	Savannah	0.04
Idaho	38.7	+2.8	Chattin's Flat	78	24	Obsidian	−11	10	1.31	−0.27	Spencer	5.27	Deer Flat	0.15
Illinois	44.1	+3.9	Greenville	87	7	5 stations	−5	2	2.25	−0.77	Charleston	6.06	Aurora	0.69
Indiana	43.4	+3.0	Princeton	83	9	Wheatfield	−7	2	3.33	−0.40	Frankfort	7.34	Farmersburg	1.60
Iowa	40.1	+5.4	3 stations	82	[2] 22	4 stations	−6	[2] 2	0.93	−0.82	Thurman	2.34	Harlan	0.10
Kansas	48.6	+4.9	Ashland	90	6	Saint Francis	−7	14	0.85	−0.60	Walnut	3.44	2 stations	T.
Kentucky	49.2	+2.8	3 stations	84	[2] 8	Farmers	4	3	3.59	−1.25	Bowling Green	6.19	Franklin	1.90
Louisiana	62.4	+1.4	Grand Cane	88	10	Kelly (near)	22	3	2.13	−2.38	Bastrop	5.95	Ludington	0.08
Maryland-Delaware	45.0	+2.5	Western Port, Md	82	26	Grantsville, Md	−3	3	2.25	−1.66	Okland, Md	3.96	State Sanatorium, Md.	1.13
Michigan	32.7	+3.4	Sodus	81	26	Ewen	−24	2	1.63	−0.41	Morenci	5.14	Marquette	0.26
Minnesota	30.6	+4.9	3 stations	79	25	Sandy Lake Dam	−27	2	0.56	−0.63	Grand Marais	2.15	Morris	0.00
Mississippi	59.5	+2.2	Kosciusko	88	13	2 stations	18	3	2.89	−2.77	Moorhead	6.77	Bay St. Louis	0.15
Missouri	47.7	+3.9	Mexico	86	9	Amoret	−5	2	1.95	−1.05	Louisiana	5.16	Galena	0.10
Montana	34.1	+3.9	Denton	80	28	Plevna	−27	14	1.13	+0.17	Heron	4.41	Kippen	0.11
Nebraska	41.7	+6.1	North Loup	88	[2] 22	Harrison	−15	14	0.69	−0.41	Auburn	2.18	Sutherland	0.02
Nevada	43.5	+2.4	Pahrump	90	20	2 stations	2	[2] 10	0.72	−0.08	Austin	1.83	Montello	0.02
New England	36.1	+5.5	Amherst, Mass	74	26	Van Buren, Me	−26	16	4.52	+0.94	Lawrence, Mass	8.21	Enosburg Falls, Vt	1.57
New Jersey	43.3	+4.5	Indian Mills	80	27	Culvers Lake	1	3	3.47	−0.49	Little Falls	6.09	Northfield	1.50
New Mexico	47.4	+3.7	Carlsbad	90	29	Elizabethtown	−7	1	0.31	−0.56	Chama	2.85	45 stations	0.00
New York	37.2	+5.7	Port Jervis	80	26	Wanakena	−20	3	3.55	+0.45	Bolton	6.36	Lauterbrunnen	0.89
North Carolina	52.2	+2.2	Goldsboro	89	11	Parker	−5	3	2.50	−1.97	Shelby	4.55	Brevard	0.85
North Dakota	27.4	+4.8	4 stations	75	25	4 stations	−26	[2] 1	0.67	−0.16	Howard	2.00	2 stations	0.05
Ohio	41.8	+2.3	Middleport	81	26	Bellefontaine	−7	3	2.63	−0.85	Paulding	5.48	Lima	1.22
Oklahoma	56.1	+4.4	Mangum	96	7	2 stations	9	2	0.83	−1.31	Antlers	6.82	4 stations	T.
Oregon	43.9	+1.9	Grants Pass	81	25	Blitzen	1	26	1.60	−1.35	Welches (near)	6.85	Vale	T.
Pennsylvania	40.9	+3.5	Catawissa	79	26	West Bingham	−15	3	2.56	−0.85	Bustleton	4.13	Herrs Island Dam	1.47
Porto Rico	73.3	−0.6	2 stations	94	31	2 stations	50	4	2.85	−0.69	Manati	8.67	Santa Rita	0.30
South Carolina	56.6	+1.6	2 stations	90	[2] 9	Caesar's Head	9	3	1.67	−2.21	Pilzer	3.52	Paris Island	0.08
South Dakota	36.9	+6.2	Forestburg	85	25	Redig	−25	14	0.32	−0.75	Hardy Ranger Sta-	3.40	6 stations	T.
Tennessee	52.2	+2.5	2 stations	85	9	Crossville	4	3	2.47	−2.97	Tiptonville	5.15	Knoxville	1.10
Texas	63.1	+4.4	2 stations	100	[2] 16	Leib (near)	13	1	0.65	−1.41	Jefferson	4.86	38 stations	0.08
Utah	41.2	+3.1	Saint George	89	19	Castle Rock	−10	11	1.21	−0.31	Silver Lake	3.60	4 stations	T.
Virginia	47.7	+1.9	Troy	88	23	Burkes Garden	−1	3	1.92	−1.90	Diamond Springs	4.05	Lexington	0.49
Washington	43.1	+1.7	Wapato	86	20	Bumping Lake	10	6	1.92	−0.99	Silverton	9.66	2 stations	T.
West Virginia	43.6	+0.9	2 stations	82	[2] 10	Cheat Bridge	−12	3	3.25	−0.77	Pickens	6.59	Romney	1.00
Wisconsin	32.5	+3.3	2 stations	76	[2] 24	Long Lake	−35	2	0.86	−0.87	Racine	1.91	2 stations	0.27
Wyoming	34.5	+4.4	Basin	77	25	Riverside	−21	[2] 10	0.70	−0.36	Dome Lake	3.39	2 stations	T.

[1] For description of tables and charts, see REVIEW, January, 1925, page 42.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau Stations, March, 1925*

Districts and stations	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dewpoint	Mean relative humidity	Precipitation: Total	Departure from normal	Days with .01, or more	Wind: Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
New England							38.4	+5.7										76	3.90	+0.1										5.5		
Eastport	76	67	85	29.98	30.07	+.14	33.8	+4.9	51	26	40	10	3	27	24	32	29	83	3.79	−0.5	18	8,342	s.	47	se.	2	10	5	16	6.3	11.3	0.0
Greenville, Me.	1,070	6		28.87	30.07		29.0		57	27	38	−4	16	20	36				4.13		15		se.				11	7	13		23.8	
Portland, Me.	103	82	117	29.96	30.09	+.13	36.7	+4.9	60	11	44	9	3	30	24	33	28	74	6.12	+2.4	15	6,912	nw.	36	se.	19	14	5	12	5.0	2.3	0.0
Concord	288	70	79	29.75	30.07	+.07	36.5	+5.7	68	27	47	4	3	26	40				5.93	+2.5	13	3,974	nw.	24	w.	2	15	6	10	4.5	4.5	0.0
Burlington	404	11	48	29.60	30.06	+.06	34.8	+5.7	69	27	43	−2	3	27	29				3.17	+1.3	13	9,881	s.	52	s.	25	5	9	17	7.0	10.8	0.0
Northfield	876	12	60	29.09	30.06	+.06	32.5	+6.1	64	27	43	−5	3	22	39	30	27	81	2.55	−0.2	14	6,406	s.	36	sw.	19	5	8	18	7.0	20.5	0.0
Boston	125	115	188	29.92	30.06	+.09	43.0	+7.4	72	27	52	11	3	35	33	37	31	68	5.21	+1.1	12	7,364	nw.	45	se.	1	12	7	12	5.4	T.	0.0
Nantucket	12	14	90	30.05	30.06	+.08	40.3	+4.8	58	27	47	15	3	34	26	37	33	85	2.18	−1.8	13	11,484	sw.	54	se.	1	11	7	13	5.4	0.0	0.0
Block Island	26	11	46	30.02	30.05	+.07	39.8	+4.4	56	27	46	13	3	34	28	37	33	79	2.17	−2.2	13	12,224	sw.	54	se.	1	13	6	12	5.3	0.0	0.0
Providence	160	215	251	29.89	30.07	+.09	41.4	+5.7	69	27	51	11	3	32	34	36	31	70	3.79	−0.8	12	7,949	nw.	66	se.	1	12	6	13	5.2	0.6	0.0
Hartford	159	122	140	29.88	30.06	+.07	42.0	+7.0	72	26	52	9	3	32	37				3.78	−0.5	15		s.				12	8	11	5.0	0.2	0.0
New Haven	106	74	153	29.95	30.07	+.08	41.8	+6.0	69	19	51	11	3	33	33	37	31	69	4.19	−0.3	14	6,976	n.	48	se.	1	15	4	12	4.8	T.	0.0
Middle Atlantic States							44.7	+4.1										72	2.38	−1.3										5.3		
Albany	97	102	115	29.97	30.08	+.07	39.2	+6.5	69	26	48	6	3	30	36	34	30	72	3.24	+0.5	12	6,988	s.	39	s.	10	14	7	10	5.1	1.5	0.0
Binghamton	871	10	84	29.11	30.06	+.04	38.4	+5.8	75	26	48	3	3	29	45				2.36	−0.3	13	5,221	nw.	42	sw.	19	7	7	17	6.7	6.9	T.
New York	314	414	454	29.72	30.07	+.07	43.6	+5.9	68	19	52	10	3	36	29	38	31	66	3.25	−0.8	12	14,037	nw.	68	se.	1	9	11	11	5.9	T.	0.0
Harrisburg	374	94	104	29.69	30.10	+.07	42.7	+3.8	72	26	52	9	3	34	32	37	30	67	2.43	−0.7	10	5,906	nw.	34	w.	19	9	8	14	5.9	0.7	0.0
Philadelphia	114	123	190	29.96	30.09	+.07	46.4	+5.6	74	27	55	11	3	37	30	40	34	66	3.15	−0.3	9	7,674	nw.	29	n.	27	13	6	12	5.3	T.	0.0
Reading	325	81	98	29.73	30.09		43.4		73	26	53	9	3	34	34	39	35	78	2.52	−1.0	9	5,545	nw.	34	w.	19	16	5	10	4.4	T.	0.0
Scranton	805	111	119	29.20	30.09	+.07	40.0	+4.3	73	26	50	5	3	30	40	35	31	76	2.11	−1.0	15	6,100	nw.	48	sw.	19	11	6	14	5.9	3.1	T.
Atlantic City	52	37	172	30.02	30.08	+.06	43.8	+5.2	70	19	50	11	3	37	26	39	35	76	1.56	−2.2	6	13,763	nw.	60	se.	1	12	9	10	5.2	T.	0.0
Cape May	17	13	49	30.09	30.11	+.10	44.6	+3.8	68	19	52	15	3	37	25	40	36	79	1.67	−2.1	8	7,270	nw.	56	se.	1	14	5	12	5.0	T.	0.0
Sandy Hook	22	10	55	30.04	30.06		42.6		67	19	49	12	3	36	24	38	33	79	2.97		10	11,824	w.	49	nw.	2	12	9	10	5.2	T.	0.0
Trenton	190	159	183	29.87	30.08		45.0		76	27	55	10	3	35	32	39	33	70	3.59	−0.4	9	8,793	nw.	43	w.	19	9	10	12	5.9	T.	0.0
Baltimore	123	100	113	29.95	30.09	+.06	46.1	+3.8	73	11	55	12	3	37	27	40	34	66	2.00	−1.9	12	4,444	nw.	34	sw.	19	12	7	12	5.3	0.3	0.0
Washington	112	62	85	29.97	30.09	+.05	46.4	+3.8	77	11	56	11	3	37	32	40	34	65	1.60	−2.2	11	5,953	s.	42	nw.	15	13	6	12	5.3	T.	0.0
Cape Henry	18	8	54	30.05	30.07		50.0		84	11	58	19	3	42	37	45	42	81	3.52	−0.8	9	11,833	n.	64	nw.	27	10	12	9	5.2	T.	0.0
Lynchburg	681	153	188	29.34	30.10	+.04	49.2	+1.9	82	11	61	11	3	37	44	43	37	68	1.06	−2.8	5	5,793	n.	40	nw.	27	15	8	8	4.6	T.	0.0
Norfolk	91	170	205	30.00	30.10	+.07	51.4	+3.2	82	11	61	16	3	42	35	44	40	73	3.29	−1.0	7	11,355	n.	56	nw.	27	13	9	9	4.8	0.0	0.0
Richmond	144	11	52	29.95	30.10	+.06	48.9	+1.7	80	11	60	14	3	38	40	44	39	74	2.47	−1.2	7	7,088	ne.	48	sw.	14	14	8	9	4.6	0.0	0.0
Wytheville	2,304	49	55	27.69	30.11	+.06	45.0	+2.7	76	9	56	7	3	34	35	38	33	69	0.68	−3.8	10	5,726	nw.	38	w.	19	15	7	9	4.3	0.6	0.0
South Atlantic States							56.5	+2.8										69	1.78	−2.4										4.3		
Asheville	2,255	70	84	27.73	30.12	+.06	48.2	+3.3	79	9	60	10	3	37	36	40	33	63	2.45	−1.5	8	7,994	nw.	37	nw.	27	14	14	3	3.8	2.7	0.0
Charlotte	779	55	62	29.25	30.10	+.05	54.2	+3.8	83	9	65	17	3	44	32	46	39	64	2.39	−2.2	7	4,191	n.	30	sw.	19	10	15	6	4.5	T.	0.0
Hatteras	11	11	50	30.06	30.07	+.03	53.6	+1.6	70	14	60	26	3	47	28	50	47	82	4.29	−1.2	9	13,542	n.	60	nw.	27	13	11	7	4.4	T.	0.0
Manteo	12	5	42				51.0		76	14		20	3		36				2.38				n.				13	7	11		0.0	0.0
Raleigh	376	103	110	29.69	30.10	+.05	53.4	+3.2	85	11	64	17	3	42	32	45	38	63	2.31	−2.0	5	6,905	sw.	37	nw.	27	13	10	8	4.9	0.0	0.0
Wilmington	78	81	91	30.02	30.11	+.06	56.6	+3.3	81	9	66	24	3	47	31	50	46	76	2.19	−1.4	6	6,481	sw.	28	w.	2	12	14	5	4.6	0.0	0.0
Charleston	48	11	92	30.05	30.10	+.04	59.2	+1.8	83	9	67	30	3	52	28	53	48	75	1.28	−2.4	5	8,317	sw.	37	n.	31	12	5	14	5.3	0.0	0.0
Columbia, S. C.	351	41	57	29.73	30.11	+.06	57.8	+2.6	86	9	69	24	3	47	36	49	44	69	0.87	−2.8	5	5,264	ne.	32	sw.	27	17	6	8	4.0	0.0	0.0
Due West	711	10	55	29.36	30.14		54.5		83	9	67	21	3	43	39				2.68		6	6,604	sw.	32	w.	2	17	7	7	3.7	0.0	0.0
Greenville, S. C.	1,039	113	122	28.99	30.10		54.4	+4.5	82	9	65	19	3	44	33	45	38	60	3.12		6	6,058	n.	43	w.	19	18	7	6	3.4	T.	0.0
Augusta	182	62	77	29.91	30.10	+.04	58.6	+2.6	87	9	71	26	3	46	41	51	47	72	0.86	−4.0	6	4,342	nw.	32	ne.	31	17	7	7	4.3	0.0	0.0
Savannah	65	150	194	30.03	30.10	+.04	61.4	+2.4	86	12	71	31	3	52	27	52	46	70	0.04	−3.6	2	9,202	nw.	38	n.	31	16	6	9	4.1	0.0	0.0
Jacksonville	43	209	245	30.05	30.10	+.04	64.0	+1.4	85	12	72	33	3	56	25	55	49	68	1.14	−2.4	7	9,138	ne.	34	ne.	7	13	9	9	4.4	0.0	0.0
Florida Peninsula							70.6	+0.1										72	1.37	−0.9										3.7		
Key West	22	10	64	30.03	30.05	.00	73.4	+0.8	83	1	79	58	6	68	17	66	63	75	0.94	−0.5	4	7,768	se.	34	n.	2	19	11	1	2.7	0.0	0.0
Miami	25	71	79	30.05	30.08		70.0	−2.0	84	2	77	48	7	63	28	63	59	72	2.74	+0.1	3	6,278	e.	29	e.	23	16	9	6	4.1	0.0	0.0
Tampa	35	79	87	30.05	30.09	+.02	68.3	+1.5	87	10	77	45	3	59	28	59	54	70	0.54	−2.3	3	4,900	ne.	26	nw.	5	13	11	7	4.2	0.0	0.0
East Gulf States							59.8	+2.3										64	2.43	−3.4										4.0		
Atlanta	1,174	190	216	28.88	30.12	+0.06	55.3	+3.3	81	9	65	18	3	45	32	46	38	58	3.68	−2.1	9	9,410	nw.	46	nw.	27	18	6	7	3.6	0.0	0.0
Macon	370	78	87	29.72	30.12	+0.06	58.2	+1.5	86	11	71	22	3	45	41	48	39	58	1.33	−4.2	7	4,741	nw.	28	nw.	2	12	12	7	4.1	0.0	0.0
Thomasville	273	49	58	29.81	30.11	+0.05	63.2	+3.0	88	12	74	29	3	52	32	52	44	61	0.70	−4.4	6	3,658	nw.	17	nw.	2	11	11	9	4.7	0.0	0.0
Apalachicola	36	42	49	30.07	30.11		63.0		85	9	70	34	3	56	27	56	52	73	2.11		6	6,116	n.	31	e.	24	15	7	9	4.1	0.0	0.0
Pensacola	56	149	185	30.07	30.12	+.06	62.2	+1.9	79	8	70	33	3	55	28	55	51	73	0.40	−5.0	6	9,336	n.	36	e.	24	16	7	8	3.9	0.0	0.0
Anniston	741	9	57	29.35	30.15	+.09	55.0	+2.5	82	11	68	18	3	42	42				4.19	−1.6	8	4,337	nw.	32	nw.	18	15	13	3	3.4	0.0	0.0
Birmingham	700	11	48	29.38	30.16	+.10	57.2	+1.8	82	11	68	23	3	46	35	47	39	57	5.47	−0.3	7	5,473	n.	35	s.	13	21	5	5	3.1	0.0	0.0
Mobile	57	125	161	30.06	30.12	+.06	62.2	+2.5	83	8	72	31	3	52	34	54	48	70	0.78	−6.4	6	7,245	n.	38	n.	27	12	11	8	4.6	0.0	0.0
Montgomery	223	100	112	29.88	30.14	+.08	60.4	+2.6	85	11	72	26	3	49	33	50	40	59	4.24	−2.1	8	5,179	nw.	36	n.	13	15	8	8	4.1	0.0	0.0
Meridian	375	85	93	29.73	30.14	+.09	58.4	+1.3	83	11	70	25	3	47	40	50	44	65	2.91	−2.7	7	4,414	ne.	22	nw.	14	17	10	4	3.8	0.0	0.0
Vicksburg	247	65	73	29.86	30.15	+.11	60.8	+2.3	83	13	71	28	3	50	32	51	43	61	1.97	−4.3	6	5,466	n.	32	w.	18	13	7	11	4.6	0.0	0.0
New Orleans	53	76	84	30.06	30.12	+.08	65.2	+2.4	85	11	74	36	3	56	29	57	52	71	1.04	−4.3	4	5,222	s.	24	e.	24	15	12	4	4.0	0.0	0.0
West Gulf States							62.9	+3.8										68	0.80	−2.2										4.4		
Shreveport	249	77	93	29.84	30.12	+.10	60.7	+2.4	83	26	71	31	3	50	36	51	43	61	4.19	−0.3	7	5,579	se.	29	s.	13	17	8	6	3.7	0.0	0.0
Bentonville	1,303	11	44				52.4	+5.1	83	26	65	10	2	40	35				0.34		3	5,804	s.	30	s.	13	26	4	1		0.6	0.0
Fort Smith	457	79	94	29.59	30.07	+.06	56.2	+3.6	85	26	68	19	2	44	34	47	40	60	0.85	−2.8	5	7,239	e.	33	sw.	18	15	10	6	3.9	0.0	0.0
Little Rock	357	136	144	29.72	30.11	+.08	56.8	+3.8	83	26	68	23	2	46	33	47	39	58	0.52	−4.4	1	7,256	s.	40	w.	18	14	9	8	4.2	0.0	0.0
Brownsville	57	53	61	29.96	30.02		69.5	+1.3	83	18	78	48	2	61	28	63	61	83	2.64		3	7,117	s.	35	s.	9	13	11	7	4.6	0.0	0.0
Corpus Christi	20	11	73	30.04	30.06	+.08	68.2	+3.2	79	13	74	51	3	62	22	63	63	85	0.90	−1.0	2	11,301	se.	47	n.	14	10	15	6	5.1	0.0	0.0
Dallas	512	109	117	29.54	30.09		62.0		88	25	74	31	15	50	50				0.40		5	7,382	s.	39	se.	6	14	11	6	3.9	0.0	0.0
Fort Worth	670	106	114	29.33	30.04	+.06	62.2	+4.5	87	25	74	30	15	51	49	51	41	50	0.02	−1.7	1	8,846	s.	36	se.	17	13	13	5	4.0	0.0	0.0
Galveston	54	106	114	30.04	30.10	+.09	66.2	+3.8	78	18	71	50	15	62	15	61	59	84	0.07	−2.8	3	8,398	se.	34	se.	29	12	14	5	4.0	0.0	0.0
Groesbeck	461	11	56	29.59	30.08		62.8		87	26	75	33	3	51	46				0.19		3	9,185	s.	37	n.	14	13	8	10	4.7	0.0	0.0
Houston	138	111	121	29.94	30.09		66.6	+3.3	83	11	76	43	3	57	32				0.94		6	6,080	e.	27	e.	20	12	14	5	4.4	0.0	0.0
Palestine	510	64	72	29.56	30.10	+.10	62.4	+3.3	84	25	73	34	15	52	39	52	44	58	0.43	−3.0	3	6,703	s.	30	s.	12	14	7	10	4.4	0.0	0.0
Port Arthur	34	58	66	30.05	30.09		65.4		81	18	73	45	3	58	23	59	56	78	0.30		5	7,674	se.	29	ne.	27	12	12	7	4.8	0.0	0.0
San Antonio	693	119	132	29.31	30.04	+.06	67.6	+4.8	87	17	79	42	15	57	38	57	49	61	0.24	−1.4	3	6,356	se.	34	ne.	14	12	11	8	4.8	0.0	0.0
Taylor	583	55	63	29.49	30.10	+.11	65.7	+6.0	87	25	78	37	3	54	41				0.01	−2.6	1	7,918	s.	35	s.	3	13	8	10	4.7	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, March, 1925*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dewpoint	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							**47.3**	**+3.1**										**66**	**2.52**	**−1.9**										**5.1**		
Chattanooga	762	189	213	29.31	30.14	+.08	54.0	+2.8	82	9	65	15	3	43	37	44	35	55	2.42	−3.8	10	6,752	n.	47	sw.	18	19	6	6	3.9	0.2	0.0
Knoxville	996	102	111	29.05	30.12	+.06	52.2	+3.5	82	9	62	18	3	42	37	44	37	65	1.10	−4.5	7	5,154	sw.	40	sw.	18	15	8	8	4.4	T.	0.0
Memphis	399	76	97	29.70	30.13	+.09	56.6	+4.3	80	13	66	24	3	47	29	47	39	59	1.48	−4.3	5	6,574	s.	43	sw.	18	16	7	8	4.2	0.0	0.0
Nashville	546	168	191	29.56	30.15	+.10	52.8	+3.6	80	8	64	16	3	42	41	44	37	61	3.34	−2.1	10	8,369	s.	46	nw.	27	16	9	6	4.2	0.2	0.0
Lexington	989	193	230	29.04	30.13	+.08	46.6	+2.8	78	9	57	8	3	36	38				3.45	−1.3	10	11,691	sw.	54	nw.	27	10	9	12	5.9	0.3	0.0
Louisville	525	188	234	29.54	30.13	+.08	48.1	+2.7	79	9	59	9	2	38	36	41	33	62	3.54	−0.8	13	9,418	s.	48	sw.	18	16	5	10	4.5	0.4	0.0
Evansville	431	139	175	29.65	30.13	+.09	48.9	+3.0	80	9	59	9	2	38	38	41	34	62	2.44	−2.2	7	9,514	sw.	60	w.	18	10	16	5	5.0	0.1	0.0
Indianapolis	822	194	230	29.20	30.10	+.06	43.2	+3.2	75	24	54	1	2	33	33	38	33	72	2.87	−1.1	8	9,888	s.	39	w.	26	13	12	6	4.4	1.4	0.0
Royal Center	736	11	55	29.28	30.10		38.6		74	24	50	−4	2	28	38				4.19		9	8,753	s.	54	nw.	10	9	13	9	5.5	3.6	0.0
Terre Haute	575	96	129	29.47	30.10		44.3		77	7	55	2	3	34	37	38	33	71	2.62		7	8,566	s.	37	s.	3	10	14	7	4.9	4.0	0.0
Cincinnati	628	11	51	29.42	30.11	+.06	44.8	+3.9	76	13	56	6	2	34	35		35	70	2.26	−1.4	13	6,938	sw.	40	sw.	18	11	11	9	4.9	0.2	0.0
Columbus	824	179	222	29.21	30.10	+.06	42.8	+3.7	75	26	53	5	3	32	32	37	31	70	2.25	−1.0	14	9,272	s.	54	w.	14	12	5	14	5.5	1.1	0.0
Dayton	899	137	173	29.12	30.10		43.1	+2.6	74	24	54	5	3	33	36	37	31	67	2.37	−1.1	12	8,339	sw.	46	sw.	18	14	8	9	4.7	0.4	0.0
Elkins	1,947	59	67	28.02	30.12	+.07	41.5	+1.5	74	10	54	0	3	30	42	36	32	78	3.91	−0.2	15	4,753	nw.	35	nw.	27	5	11	15	6.8	5.8	0.5
Parkersburg	638	77	84	29.45	30.12	+.07	45.8	+3.0	77	26	57	7	3	35	39	38	32	67	2.19	−1.6	8	5,250	nw.	32	sw.	14	8	9	14	6.2	T.	0.0
Pittsburgh	842	353	410	29.17	30.09	+.05	42.4	+2.8	74	26	52	6	3	32	34	37	31	69	1.61	−1.4	11	8,885	nw.	49	sw.	19	5	6	20	7.3	0.5	0.0
Lower Lake Region							**37.5**	**+4.4**										**74**	**2.98**	**+0.4**										**6.1**		
Buffalo	767	247	280	29.21	30.06	+.04	35.8	+4.7	68	26	43	3	2	28	31	32	29	79	2.35	−0.3	14	13,021	sw.	84	sw.	19	5	12	14	6.8	4.7	0.0
Canton	448	10	61	29.52	30.02		34.1	+4.4	66	27	42	−4	3	26	35				2.37	+0.8	14	9,087	sw.	80	sw.	19	13	4	14	5.5	12.1	T.
Oswego	335	76	91		30.06	+.05	35.6	+4.4	62	26	43	6	3	28	30			78	2.39	−0.4	15		s.	36	sw.	10	5	5	21		7.9	0.0
Rochester	523	86	102	29.48	30.06	+.04	37.7	+5.9	73	26	46	4	3	29	35	33	27	69	2.51	−0.4	17	6,327	sw.	48	sw.	19	6	8	17	7.1	3.6	0.0
Syracuse	597	97	113	29.41	30.07	+.05	37.2	+5.8	72	26	46	5	3	29	36				2.71	+0.3	14	9,941	sw.	58	s.	19	7	8	16	6.9	7.5	0.0
Erie	714	130	166	29.28	30.06	+.04	38.0	+4.5	74	26	47	3	2	29	34	34	30	77	2.64	0.0	15	10,610	s.	60	sw.	19	7	5	19	6.8	1.8	0.0
Cleveland	762	190	201	29.24	30.08	+.05	39.0	+4.4	74	26	48	3	3	30	33	34	29	71	2.95	+0.2	16	11,080	s.	45	sw.	19	7	9	15	6.3	2.4	0.0
Sandusky	629	62	70	29.39	30.09	+.06	39.9	+4.8	74	26	48	4	2	31	30				2.21	−0.3	14	7,504	sw.	31	w.	19	7	12	12	6.1	1.7	0.0
Toledo	628	208	243	29.39	30.09	+.06	38.8	+3.5	72	10	48	3	2	30	35	34	29	71	4.89	+2.6	12	11,197	sw.	56	sw.	10	11	11	9	4.9	3.4	0.0
Fort Wayne	856	113	124	29.15	30.10		39.6	+0.7	74	26	50	2	3	29	34	34	30	75	4.72		9	7,651	s.	47	sw.	10	15	8	8	4.7	4.9	0.0
Detroit	730	218	258	29.27	30.09	+.06	37.2	+3.8	71	24	46	0	2	29	32	31	26	71	3.44	+1.1	13	8,830	nw.	40	w.	21	10	10	11	5.5	8.4	0.0
Upper Lake Region							**31.5**	**+3.0**										**76**	**1.28**	**−1.0**										**5.6**		
Alpena	609	13	92	29.37	30.06	+.03	29.8	+4.3	70	26	39	−5	2	21	35	27	22	76	1.35	−0.7	12	10,864	nw.	39	e.	9	5	13	13	6.2	9.8	0.0
Escanaba	612	54	60	29.39	30.08	+.04	27.6	+3.4	68	26	37	−10	2	19	39	24	20	75	0.87	−1.1	6	9,171	n.	39	n.	14	15	9	7	4.2	6.6	0.0
Grand Haven	632	54	89	29.37	30.07	+.04	34.4	+2.7	67	26	43	4	2	26	30	31	27	78	1.34	−1.2	10	10,153	s.	35	w.	21	7	12	12	6.1	10.7	0.0
Grand Rapids	707	70	87	29.29	30.08	+.05	36.4	+3.0	74	26	46	0	2	27	32	31	26	71	1.39	−1.1	9	5,359	nw.	26	w.	21	9	9	13	5.8	7.0	0.0
Houghton	668	62	99	29.30	30.06	+.02	24.8	+2.0	60	25	34	−11	2	15	44				1.18	−0.9	11	7,711	e.	50	w.	10	11	9	11	5.6	8.6	T.
Lansing	878	11	62	29.10	30.07		34.6	+2.4	75	26	45	−8	2	24	36	30	27	81	2.45	+0.2	10	5,975	sw.	26	sw.	24	10	13	8	5.2	12.6	0.0
Ludington	637	60	66	29.35	30.07		32.8		62	26	40	3	2	26	28	30	26	77	0.81		8	10,202	s.	45	sw.	3	8	14	9	5.7	7.6	0.0
Marquette	734	77	111	29.26	30.09	+.05	27.8	+3.0	70	26	36	−9	2	20	29	24	20	77	0.26	−1.8	11	8,750	nw.	47	sw.	23	7	10	14	6.3	2.3	0.0
Port Huron	638	70	120	29.35	30.06	+.03	34.3	+3.9	70	26	42	−2	2	26	32	31	27	78	2.56	+0.1	12	10,404	s.	50	ne.	19	7	14	10	5.8	4.0	0.0
Saginaw	641	69	77	29.36	30.07		33.2	+1.7	74	26	42	−5	2	24	33	30	26	75	1.86	−0.8	8	8,188	nw.	32	s.	3	7	10	14	6.6	13.5	0.0
Sault Sainte Marie	614	11	52	29.35	30.07		24.6	+3.0	52	26	34	−11	2	16	37	22	18	80	0.79	−1.1	10	7,876	nw.	42	nw.	21	8	12	11	6.0	5.3	T.
Chicago	823	140	310	29.18	30.09	+.06	39.7	+3.4	76	26	48	−1	2	31	31	34	29	71	1.51	−1.0	7	10,045	n.	42	s.	20	10	12	9	5.1	3.2	0.0
Green Bay	617	109	141	29.37	30.05	+.01	31.8	+3.3	66	26	40	−9	2	23	31	28	24	76	0.59	−1.8	6	10,707	s.	44	ne	13	10	8	13	5.6	6.1	0.0
Milwaukee	681	125	139	29.32	30.07	+.01	36.1	+4.0	72	26	44	−4	2	28	27	32	27	74	1.10	−1.6	6	9,386	sw.	36	s.	20	8	12	11	5.9	10.9	0.0
Duluth	1,133	5	47	28.80	30.06	.00	26.2	+2.5	64	25	35	−17	2	17	32	22	18	77	0.66	−0.9	6	10,504	ne.	45	nw.	1	13	9	9	4.5	2.8	0.0
North Dakota							**28.4**	**+6.3**										**72**	**0.78**	**−0.2**										**4.9**		
Moorhead	940	50	58	29.00	30.04	−.04	29.6	+6.9	71	25	40	−13	2	20	38	26	21	72	0.73	−0.4	7	7,130	nw.	30	nw.	10	16	8	7	4.3	3.0	0.0
Bismarck	1,674	8	57	28.23	30.07	+.01	31.6	+7.4	75	25	43	−8	14	20	44	26	19	65	0.46	−0.6	4	9,113	nw.	48	nw.	20	15	10	6	4.1	2.5	0.0
Devils Lake	1,478	11	44	28.40	30.03	−.02	24.6	+6.1	61	25	35	−21	1	14	46	21	18	79	0.80	−0.2	7	8,622	nw.	40	nw.	26	9	10	12	5.5	7.5	0.0
Ellendale	1,457	10	56	28.45	30.05		31.6		75	25	44	−6	1	20	40				0.45		5	12,663	nw.	52	nw.	26	11	9	11	5.5	2.5	0.0
Grand Forks	835	12	89				24.7		61	29	36	−17	1	14	42	21			1.12		6		nw.	48	s.	2	16	7	8		4.9	0.0
Williston	1,878	41	48	27.97	30.01	−.03	27.6	+4.7	66	29	38	−20	14	17	44	24	18	70	1.15	+0.5	8	7,123	w.	39	w.	20	8	16	7	5.3	11.5	0.0
Upper Mississippi Valley							**40.9**	**+4.8**										**68**	**1.32**	**−1.1**										**4.7**		
Minneapolis	918	102	208	29.03	30.03		35.2	+5.6	73	23	44	−3	1	26	32				0.44	−1.2	4	10,024	nw.	39	nw.	26	11	10	10	5.2	0.3	0.0
St Paul	837	236	261	29.12	30.05	.00	34.6	+5.5	71	23	44	−4	1	26	31				0.39	−1.2	3	10,761	nw.	50	w.	10	8	18	5	4.8	0.8	0.0
La Crosse	714	11	48	29.28	30.07	+.03	36.6	+5.1	72	23	47	−4	2	26	34				0.96	−0.7	5	5,122	se.	27	se.	20	6	13	12	6.1	9.0	0.0
Madison	974	70	78	29.01	30.09	+.05	35.1	+4.5	66	26	44	−5	2	26	31	30	25	70	1.45	−0.8	7	8,797	nw.	42	ne	13	9	10	12	5.9	9.4	0.0
Wausau	1,247	4		28.62	30.00		30.0		62	26	40	−11	2	20	36				0.57		4		s.				7	11	13	6.0	2.1	0.0
Charles City	1,015	10	49	28.97	30.08	+.03	36.2	+5.5	76	23	47	−1	2	25	38	31	25	70	0.96	−1.0	5	6,411	nw.	29	s.	20	15	12	4	4.0	5.0	0.0
Davenport	606	71	79	29.41	30.09	+.06	40.9	+4.8	71	25	52	0	2	30	36	36	32	77	1.13	−1.1	6	6,626	nw.	32	s.	20	13	13	5	4.4	0.6	0.0
Des Moines	861	84	97	29.14	30.07	+.03	41.2	+5.3	78	23	52	4	2	30	35	34	27	63	0.88	−0.8	6	6,477	sw.	38	sw.	20	12	9	10	5.4	2.6	0.0
Dubuque	698	81	96	29.29	30.06	+.02	38.4	+4.4	69	23	49	−1	2	28	33	33	26	65	1.03	−1.2	6	6,085	nw.	28	s.	20	8	14	9	5.8	3.0	0.0
Keokuk	614	64	78	29.41	30.10	+.07	43.4	+4.5	76	23	55	3	2	32	37	37	30	65	0.95	−1.4	6	6,571	s.	30	s.	20	12	12	7	4.8	1.7	0.0
Cairo	356	87	93	29.72	30.11	+.07	51.8	+4.6	81	8	62	11	2	42	33	43	35	60	2.19	−1.8	8	8,021	s.	54	sw.	18	13	7	11	5.0	1.3	0.0
Peoria	609	11	45	29.43	30.11	+.08	41.1	+4.1	74	7	53	−2	2	29	37	36	31	74	1.58	−1.4	4	6,256	s.	24	s.	3	16	11	4	3.6	7.3	0.0
Springfield, Ill	644	10	91	29.39	30.08	+.05	43.8	+3.6	77	24	55	3	2	33	38	38	33	73	2.94	−0.1	4	7,216	s.	31	s.	3	19	5	7	3.6	1.5	0.0
Hannibal	534	74	109	29.52	30.11	+.09	45.2	+4.2	77	23	57	4	2	34	38				2.09	−0.7	6	7,131	nw.	34	s.	20	17	8	6	3.8	1.3	0.0
St. Louis	567	265	303	29.48	30.10	+.07	48.6	+4.8	81	24	59	7	2	38	37	40	32	61	1.50	−1.9	7	10,552	s.	48	s.	3	18	9	4	3.6	T.	0.0
Missouri Valley							**43.4**	**+6.1**										**60**	**0.91**	**−1.0**										**4.5**		
Columbia, Mo	784	11	84	29.25	30.10	+.07	47.0	+4.4	78	6	59	4	2	35	37				2.63	−0.4	9	7,267	s.	31	nw.	26	16	10	5	4.0	1.2	0.0
Kansas City	963	161	181	29.02	30.08	+.06	46.6	+3.9	76	23	58	7	2	36	32	40	33	64	1.26	−1.6	8	8,874	s.	40	n.	26	14	13	4	4.0	2.2	0.0
St. Joseph	967	11	49	29.01	30.07		45.4		78	23	57	6	2	34	38	37	29	61	1.46		6	7,489	nw.	40	sw.	20	16	11	4	3.5	0.4	0.0
Springfield, Mo	1,324	98	104	28.67	30.09	+.07	50.1	+4.9	82	8	61	4	2	39	33	41	32	58	1.07	−3.0	4	9,476	s.	38	sw.	10	22	5	4	2.9	1.8	0.0
Iola	984	11	50	29.00	30.06	+.05	49.7	+7.3	82	7	64	5	2	35	37				1.69	−0.7	6	6,385	s.	28	ne.	18	15	10	6	4.4	0.4	0.0
Topeka	987	92	107				46.6	+4.0	79	6	59	4	2	34	39				1.15	−1.1	7	9,008	sw.	42	sw.	20	15	9	7	4.1	2.6	0.0
Drexel	1,299	10	54	28.63	30.05		40.4		80	23	52	3	2	29	37				1.33		6	9,897	n.	44	sw.	23	8	12	11	5.5	9.5	0.0
Lincoln	1,189	11	84	28.77	30.06	+.04	43.4	+5.9	82	23	55	5	2	32	36	36	27	60	1.28	0.0	6	8,540	s.	41	nw.	26	9	12	10	5.8	3.0	0.0
Omaha	1,105	115	122	28.87	30.07	+.03	43.2	+6.2	82	23	54	6	2	32	35	35	26	57	0.75	−0.6	6	7,165	nw.	37	n.	13	11	12	8	4.9	5.8	0.0
Valentine	2,598	47	54	27.26	30.03	.00	38.5	+6.2	80	25	52	−6	2	25	64	31	22	58	0.26	−0.9	6	8,861	w.	44	nw.	25	12	13	6	4.8	2.4	0.0
Sioux City	1,135	94	164	28.83	30.08	+.03	40.6	+7.9	80	25	52	6	2	30	35	33	26	62	0.33	−0.9	4	11,251	nw.	50	nw.	26	9	16	6	4.9	3.0	0.0
Huron	1,306	59	74	28.64	30.08	+.02	37.0	+8.1	79	25	49	1	2	25	44	30	20	59	0.06	−0.9	3	8,837	nw.	38	nw.	25	13	13	5	4.4	0.2	0.0
Pierre	1,572	70	75	28.36	30.07	+.02	38.6	+7.1	80	25	51	2	2	26	50	31	21	59	0.05	−1.3	2	9,228	nw.	52	nw.	25	8	12	11	5.4	0.4	0.0
Yankton	1,233	49	57	28.71	30.06	+.01	40.0	+6.8	80	25	51	5	2	28	38				0.44	−0.7	1	7,409	nw.	34	nw.	26	13	13	5	4.8	4.5	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, March, 1925*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dewpoint	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F,	°F.	K	In.	In.		Miles								0–10	In.	In.
Northern Slope							35.8	+4.5										62	0.69	−0.4										5.9		
Billings	3,140	5					37.8		74	28	51	−7	14	24	52				0.81		9		sw.				15	6	10			
Havre	2,505	11	44	27.30	30.00	.00	30.9	+3.8	70	28	42	−11	13	20	41	28	24	77	0.70	+0.2	10	5,946	sw.	48	w.	25	6	9	16	6.6	6.0	0.0
Helena	4,110	87	112	25.74	29.99	−.02	37.1	+4.7	66	27	47	0	13	27	38	30	21	57	1.00	+0.3	10	6,577	sw.	38	w.	25	2	10	19	7.7	9.1	0.0
Kalispell	2,973	48	56	26.88	29.98	−.01	35.9	+3.0	61	28	44	6	13	28	29	31	24	64	1.13	0.0	14	4,811	nw.	36	sw.	22	5	16	10	6.3	4.7	0.0
Miles City	2,371	48	55	27.45	30.06	+.04	34.8	+6.2	76	29	46	−13	14	24	43	30	23	68	0.79	0.0	10	5,819	ne.	36	nw.	25	4	18	9	5.9	7.5	0.0
Radid City	3,259	50	58	26.57	30.05	+.04	36.6	+4.0	72	25	49	−11	14	24	52	31	23	60	0.56	−0.5	5	6,485	se.	38	nw.	25	8	9	14	6.0	4.2	0.0
Cheyenne	6,088	84	101	23.94	29.97	+.01	37.3	+4.2	64	29	50	−2	14	25	41	30	19	51	0.59	−0.4	5	12,830	w.	64	w.	20	10	14	7	5.0	3.0	0.0
Lander	5,372	60	68	24.57	29.98	−.01	37.4	+5.0	64	22	52	7	14	23	42	31	23	60	0.18	−1.4	2	5,232	w.	48	w.	2	13	15	3	4.5	1.2	0.0
Sheridan	3,790	10	47	26.05	30.01		36.8		72	22	50	−1	14	24	53	30	21	58	0.96		9	5,131	nw.	36	nw.	9	6	15	10	6.0	7.8	0.0
Yellowstone Park	6,241	11	48	23.81	30.03	+.01	29.8	+3.3	56	27	39	−1	10	21	41	25	18	63	1.00	−1.2	14	7,535	s.	42	s.	25	4	15	12	6.5	11.5	T.
North Platte	2,821	11	51	27.08	30.05	+.05	42.8	+6.2	79	25	57	1	14	29	49	34	25	60	0.22	−0.6	1	6,949	n.	34	n.	17	15	8	8	4.5	1.8	0.0
Middle Slope							49.0	+5.7										49	0.64	−0.8										3.7		
Denver	5,292	106	113	24.67	29.97	+.02	44.5	+5.2	72	5	58	9	14	32	46	33	19	43	0.42	−0.6	4	6,931	s.	46	se.	29	16	11	4	3.9	7.5	0.0
Pueblo	4,685	80	86	25.24	29.94	+.02	47.4	+5.8	77	5	64	11	11	31	54	36	20	41	0.27	−0.6	5	6,476	nw.	39	nw.	17	16	14	1	3.5	2.7	0.0
Concordia	1,392	50	58	28.55	30.05	+.04	46.6	+5.6	80	23	59	6	2	34	38	37	27	54	1.67	+0.2	6	7,243	s.	32	nw.	26	10	15	6	5.0	0.2	0.0
Dodge City	2,509	11	51	27.42	30.05	+.08	49.2	+6.4	88	6	64	14	14	34	49	38	27	52	0.64	−0.2	5	9,064	se.	54	se.	9	17	10	4	3.2	0.9	0.0
Wichita	1,358	139	158	28.59	30.03	+.04	50.4	+5.3	80	6	63	9	2	38	40	41	32	55	0.54	−1.7	6	12,028	s.	60	sw.	20	16	14	1	3.5	0.0	0.0
Broken Arrow	765	11	56	29.24	30.08		53.8		83	8	67	14	2	41	39				1.90		4	11,679	s.	48	n.	1	17	10	4	3.5	0.0	0.0
Muskogee	652	4					57.3		85	7	71	16	2	43	42				1.59		5		se.				14	11	6		0.0	0.0
Oklahoma City	1,214	10	47	28.76	30.06	+.08	56.0	+6.0	85	25	69	19	2	43	41	45	34	51	0.28	−2.1	2	9,230	s.	36	s.	6	19	9	3	3.1	0.0	0.0
Southern Slope							59.6	+5.0										35	0.14	−0.8										3.1		
Abilene	1,738	10	52	28.22	30.02	+.06	62.7	+6.2	90	29	77	26	15	49	42	48	32	40	0.02	−1.4	1	8,930	s.	38	s.	6	15	6	10	4.1	0.0	0.0
Amarillo	3,676	10	49	26.27	30.00	+.05	53.4	+6.5	85	25	68	20	14	38	43	40	25	41	0.11	−0.5	3	8,472	sw.	35	s.	20	23	6	2	2.6	0.0	0.0
Del Rio	944	64	71	29.05	30.03	+.08	67.6	+4.1	89	17	79	38	2	56	40				0.42	−0.8	1	7,380	se.	31	n.	14	14	11	6	3.8	0.0	0.0
Roswell	3,566	75	85	26.36	29.96	+.06	54.6	+3.3	85	30	73	21	1	36	50	39	13	24	T.	−0.6	0	6,963	s.	48	s.	8	24	7	0	1.9	0.0	0.0
Southern Plateau							54.1	+3.3										37	0.25	−0.2										2.9		
El Paso	3,762	110	133	26.19	29.93	+.05	60.1	+4.3	84	5	75	33	2	46	42	42	16	20	T.	−0.4	0	8,067	w.	51	w.	12	25	6	0	2.2	0.0	0.0
Santa Fe	7,013	38	53	23.23	29.96	+.07	43.4	+3.7	69	31	56	17	1	31	31	32	18	40	0.59	−0.1	4	5,711	n.	32	w.	12	15	12	4	3.6	T.	0.0
Flagstaff	6,907	10	59	23.34	29.96	+.05	38.8	+2.9	66	4	53	7	11	24	44	31		54	1.21		5	6,610	sw.	34	s.	6	14	11	6		7.5	0.0
Phoenix	1,108	10	82	28.79	29.94	+.03	65.0	+4.3	94	20	81	38	13	49	47	49	33	37	0.33	−0.2	2	3,700	e.	28	sw.	29	20	7	4	3.1	0.0	0.0
Yuma	141	9	54	29.80	29.95	+.01	65.9	+1.8	94	20	81	40	13	50	45	50	30	33	0.35	0.0	2	4,502	n.	33	nw.	30	19	10	2	2.7	0.0	0.0
Independence	3,957	5	25	25.99	30.04	+.10	51.4	+2.9	79	21	67	22	8	36	44	37			T.	−0.5	0		nw.				13	10	8	2.8	T.	0.0
Middle Plateau							42.9	+2.0										50	1.12	−0.1										4.5		
Reno	4,532	74	81	25.46	30.02	+.04	43.4	+2.4	74	4	56	16	11	30	42	35	24	52	0.56	−0.3	3	5,878	w.	42	w.	2	19	4	8	3.8	3.6	0.0
Tonopah	6,090	12	20				42.2		66	21	52	16	11	33	29	33	22	50	0.26		5		se.								0.0	0.0
Winnemucca	4,344	18	56	25.62	30.04	+.03	41.6	+1.6	73	22	56	10	11	27	47	33	23	55	1.24	+0.3	7	5,858	sw.	31	w.	16	13	7	11	5.2	9.4	0.0
Modena	5,479	10	43	24.60	30.00	+.04	39.2	+1.0	69	22	54	−4	11	24	46	31	20	52	1.33	0.0	7	8,343	w.	60	sw.	29	17	7	7	3.5	10.7	0.0
Salt Lake City	4,360	163	203	25.61	30.01	+.03	44.8	+3.1	70	22	54	24	10	35	30	36	25	49	1.71	−0.3	8	5,768	nw.	42	s.	6	12	7	12	5.2	9.1	0.0
Grand Junction	4,602	60	68	25.38	29.98	+.04	45.4	+1.8	72	23	58	23	14	33	36	35	22	44	0.74	0.0	7	4,960	se.	48	sw.	30	14	7	10	4.7	1.0	0.0
Northern Plateau							43.6	+2.2										57	0.73	−0.8										6.5		
Baker	3,471	48	53	26.45	30.07	+.04	39.4	+1.8	66	21	50	20	11	29	35	34	25	62	0.58	−0.9	5	4,516	se.	26	nw.	25	6	10	15	6.5	3.1	0.0
Boise	2,739	78	86	27.18	30.07	+.04	44.7	+2.0	69	4	55	24	11	34	33	37	27	55	0.87	−0.6	9	4,128	se.	30	nw.	25	7	13	11	5.7	1.5	0.0
Lewiston	757	40	48	29.23	30.05	+.02	46.8	+1.4	69	31	57	28	8	36	33				0.30	−1.0	7	3,240	e.	30	nw.	25	5	7	19	7.5	0.0	0.0
Pocatello	4,477	60	68	25.45	30.01	.00	41.6	+4.2	64	22	51	20	10	32	36	34	25	55	0.88	−0.9	9	8,360	s.	44	s.	30	5	16	10	6.4	3.9	0.0
Spokane	1,929	101	110	27.95	30.03	+.02	41.6	+1.9	62	27	50	25	13	33	27	36	29	62	0.67	−0.8	9	5,256	s.	30	sw.	25	4	9	18	7.1	0.7	0.0
Walla Walla	991	57	65	28.96	30.04	+.02	47.8	+1.7	69	21	57	29	10	39	33	41	31	53	1.07	−0.8	8	4,634	s.	26	w.	25	8	10	13	6.0	T.	0.0
North Pacific Coast Region							45.8	+0.6										76	2.51	−1.9										6.8		
North Head	211	11	56	29.89	30.13	+.12	44.8	−0.4	64	1	49	36	29	40	23	42	39	83	3.62	−1.6	21	9,931	n.	55	s.	16	2	3	26	8.5	0.0	0.0
Port Angeles	29	8	53		30.11		43.0		54	19	49	32	30	37	19				2.04	−0.1	14	5,121	s.	34	nw.	4	4	9	18		0.0	0.0
Seattle	125	215	250	29.99	30.12	+.13	44.9	0.0	60	26	50	35	28	39	24	41	37	74	1.22	−1.7	13	6,986	s.	34	s.	24	4	8	19	7.4	0.0	0.0
Tacoma	194	172	201	29.88	30.10	+.10	45.1	+0.9	61	1	52	33	10	39	27				1.03	−2.5	12	5,114	n.	29	sw.	4	3	11	17	7.5	0.0	0.0
Tatoosh Island	86	9	53	29.99	30.09	+.13	44.1	+1.2	52	1	48	38	29	40	11	42	39	84	6.74	−1.8	17	11,174	w.	60	e.	26	6	11	14	6.7	0.0	0.0
Yakima	1,071	5					45.4		74	21	60	23	29	31	41				0.13		2		nw.				5	16	10	5.5	0.0	0.0
Medford	1,425	4					47.6		76	24	61	26	11	34	47	40	34	66	1.04		8		n.				9	3	19	5.4	0.0	0.0
Portland, Oreg.	153	68	106	29.94	30.10	+.08	47.4	+0.5	65	21	55	32	6	40	26	44	41	80	1.76	−2.9	14	4,342	nw.	25	s.	19	4	5	22	7.7	0.0	0.0
Roseburg	510	9	57	29.57	30.12	+.08	48.4	+1.3	74	26	58	31	36	38	43	43	37	70	1.15	−2.8	11	2,287	nw.	21	sw.	16	4	20	7	5.7	0.0	0.0
Middle Pacific Coast Region							53.0	+0.7										72	2.19	−1.8										4.2		
Eureka	62	73	80	30.05	30.12	+.06	47.9	−0.4	72	1	54	35	11	42	26	45	42	83	2.02	−5.0	10	4,947	n.	29	n.	12	8	11	12	5.5	0.0	0.0
Point Reyes	490	7	18	29.48	30.00		50.2	+0.6	67	1	55	40	9	46	19				3.25		7	13,023	nw.	58	s.	30	11	14	6	5.0	0.0	0.0
Red Bluff	332	50	56	29.67	30.03	−.01	55.8	+2.2	91	21	67	32	10	44	41	48	39	61	3.29	−0.5	5	4,457	nw.	26	se.	27	20	5	6	3.2	0.0	0.0
Sacramento	69	106	117	29.97	30.04	+.01	54.5	+0.2	81	24	64	36	10	44	36	50	45	72	1.14	−1.9	5	5,451	se.	29	se.	30	18	9	4	3.0	0.0	0.0
San Francisco	155	208	243	29.89	30.06	.00	55.4	+1.2	79	21	63	43	11	48	29	49	45	74	2.63	−0.5	7	5,841	w.	32	nw.	8	14	13	4	3.8	0.0	0.0
San Jose	141	12	110	29.91	30.06		54.2	+0.5	81	21	67	32	11	42	43				1.88	−1.1	9	4,306	nw.	27	nw.	8	13	10	8	4.4	0.0	0.0
South Pacific Coast Region							56.8	+0.9										68	2.31	−0.3										4.3		
Fresno	327	89	98	29.69	30.05	+.04	56.8	+1.8	83	21	68	33	11	45	33	50	44	67	1.68	−0.1	8	4,208	nw.	28	s.	29	14	9	8	4.2	0.0	0.0
Los Angeles	338	159	191	29.66	30.03	+.01	58.8	+1.8	85	19	68	43	8	50	30	49	41	60	1.56	−1.4	5	4,096	sw.	24	se.	29	15	9	7	3.9	0.0	0.0
San Diego	87	62	70	29.94	30.04	+.02	57.2	+0.5	80	1	64	44	13	50	27	51	46	72	1.78	+0.1	8	4,520	nw.	38	s.	29	13	6	12	4.5	0.0	0.0
San Luis Obispo	201	32	40	29.85	30.07	+.01	54.6	−0.1	85	19	66	34	9	43	39	48	42	71	4.21	+0.2	9	2,796	n.	22	s.	29	12	12	7	4.7	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.88	29.97		74.7	−0.7	86	31	80	65	23	70	18				2.88	−0.3	18	10,489	e.	40	e.	18	3	20	8	5.6	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.75	29.87	+.01	79.5	−1.7	92	18	90	66	10	69	24	72	70	82	0.07	−0.6	1	8,382	nw.	28	nw.	30	9	22	0	4.3	0.0	0.0
Colon	36	7	97	29.86	29.89	+.01	81.2	+0.7	87	17	86	73	25	76	13	73	71	78	0.31	−1.2	6	12,648	n.	30	n.	15	16	15	0	3.7	0.0	0.0
Alaska																																
Juneau	80	11	54				33.0		43	19	37	11	28	29	18	30	27	80	6.52		22	5,451	se.	31	e.	1	3	2	26	8.7	15.8	0.4

TABLE 2.—*Data furnished by the Canadian Meteorological Service, March, 1925*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20	30.02	30.04	+.14	25.8	+5.5	30.8	20.8	43	0	2.75	+0.02	22.7
Quebec, Que.	296	29.73	30.07	+.11	27.5	+6.3	33.9	21.1	46	-6	3.15	-0.11	25.9
Montreal, Que.	187	29.81	30.03	+.03	31.7	+7.9	38.3	25.1	55	-5	2.94	-0.85	16.9
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.76	30.04	+.03	31.0	+9.5	39.6	22.5	61	-9	3.33	+0.61	14.8
Kingston, Ont.	285	29.72	30.04	+.03	32.5	+6.9	39.0	25.9	58	-4	3.07	+0.43	5.1
Toronto, Ont.	379	29.62	30.05	+.03	34.9	+7.6	42.0	27.7	62	1	2.86	+0.22	7.3
Cochrane, Ont.	930				15.1		26.4	3.8	49	-23	0.80		8.0
White River, Ont.	1,244	28.65	30.02	-.01	13.8	+1.6	29.4	-1.8	55	-46	0.84	-0.54	8.4
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.30			30.4	+5.7	38.6	22.3	68	-5	3.15	+0.50	16.1
Parry Sound, Ont.	688	29.31	30.02	.00	27.1	+6.0	36.1	18.2	60	-8	3.54	+1.31	29.3
Port Arthur, Ont.	644												
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.14	30.03	-.03	17.8	+5.3	26.9	8.8	56	-28	1.46	+0.81	14.6
Le Pas, Man.	860				13.2		25.9	0.6	55	-32	0.55		5.5
Qu'Appelle, Sask.	2,115	27.66	29.99	-.05	20.2	+5.3	29.7	10.7	52	-24	1.68	+0.91	16.8
Medicine Hat, Alb.	2,144	27.59	29.90	-.10	28.5	+1.0	37.8	19.2	62	-14	0.84	+0.08	6.5
Moose Jaw, Sask.	1,759				22.7		32.7	12.7	61	-23	1.53		12.5
Swift Current, Sask.	2,392	27.37	29.98	-.04	24.1	+2.1	33.6	14.5	56	-15	0.91	+0.10	9.1
Calgary, Alb.	3,428	26.29	29.97	+.02	27.6	+1.4	39.4	15.8	60	-22	1.45	+0.73	14.5
Banff, Alb.	4,521	25.25	29.93	-.01	28.1	+7.9	38.5	17.7	51	-22	0.45	-0.96	3.6
Edmonton, Alb.	2,150	27.57	29.90	-.06	22.0	-2.2	32.6	11.5	51	-21	0.63	-0.09	6.2
Prince Albert, Sask.	1,450	28.39	30.03	-.05	17.0	+5.0	28.8	5.2	45	-30	0.40	-0.37	2.1
Battleford, Sask.	1,592	28.19	30.00	-.06	17.5	+4.4	28.7	6.4	43	-32	0.50	+0.04	5.0
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.83	30.09	+.12	44.7	+2.8	50.0	39.5	55	35	2.00	-1.12	0.0
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.94	30.11	+.03	63.8	+1.6	69.5	58.2	75	51	7.64	+2.51	0.0

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Barkerville, B. C.	4,180	25.40	29.79	-.13	22.5	+3.6	29.7	15.4	37	-2	4.10	+1.04	41.0
Kamloops, B. C.	1,262	28.59	29.91	-.05	32.1	+3.8	38.5	25.6	50	8	0.89	+0.10	5.5
Banff, Alb.	4,521	25.15	29.85	-.13	22.7	+3.5	33.8	11.6	43	-16	0.97	+0.05	9.7
Edmonton, Alb.	2,150	27.57	29.98	-.04	7.0	-1.3	14.8	-0.8	44	-32	1.70	+1.03	17.0
Calgary, Alb.	3,428	26.25	29.96	-.03	17.0	+3.5	27.9	6.2	49	-22	0.41	-0.22	4.1
Medicine Hat, Alb.	2,144	27.57	29.92	-.13	18.1	+6.9	26.5	9.8	54	-16	0.06	-0.61	0.6
White River, Ont.	1,244	28.55	29.94	-.08	2.5	+2.3	17.7	-12.6	37	-48	0.76	-0.76	6.8
Kingston, Ont.	285	29.67	29.99	- 05	25.5	+7.7	32.4	18.7	51	-5	3.94	+1.40	2.1
Montreal, Que.	187	29.76	29.98	-.04	22.7	+8.2	30.2	15.1	44	-2	3.41	+0.34	12.2
Chatham, N. B.	28	29.91	29.95	-.01	18.7	+6.2	29.8	7.5	47	-24	2.30	-0.86	8.5
Yarmouth, N. S.	65	29.91	29.98	-.01	31.7	+5.9	39.0	24.4	54	3	1.88	-2.86	4.3
Halifax, N. S.	88	29.94	30.05	+.10	29.2	+6.8	36.4	22.0	46	-2	3.41	-1.75	5.4
Sydney, C. B. I.	48	30.03	30.08	+.16	26.7	+7.4	35.0	18.4	50	-8	3.22	-0.87	10.0
Charlottetown, P. E. I.	38	29.98	30.02	+.07	25.4	+7.8	33.0	17.9	47	-10	1.88	-1.18	9.0

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Chart I. Tracks of Centers of Anticyclones, March 1925. (Inset) Departure of Monthly Mean Pressure from Normal

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(Plotted by Wilfred P. Day)

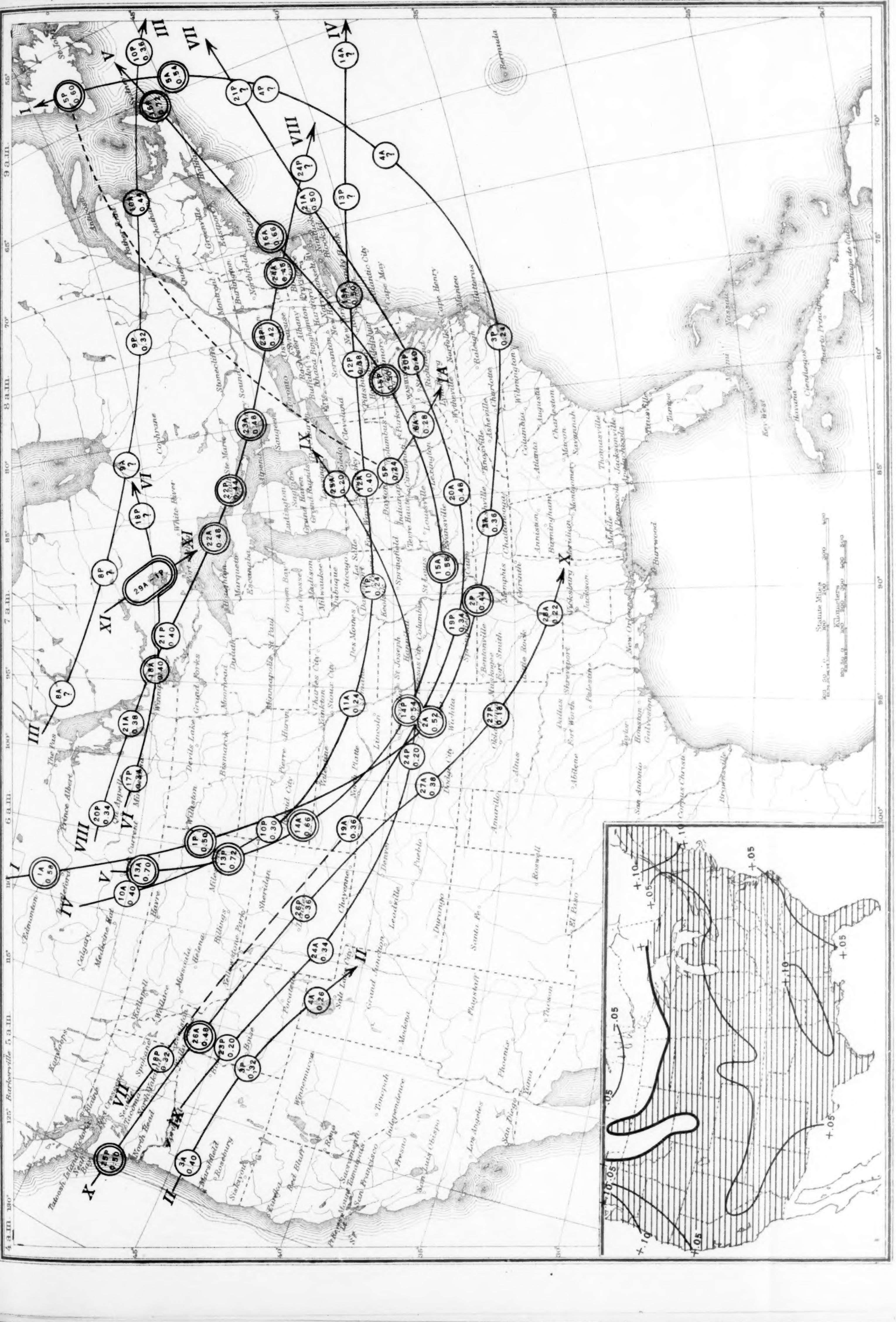

Chart II. Tracks of Centers of Cyclones, March, 1925. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Wilfred P. Day)

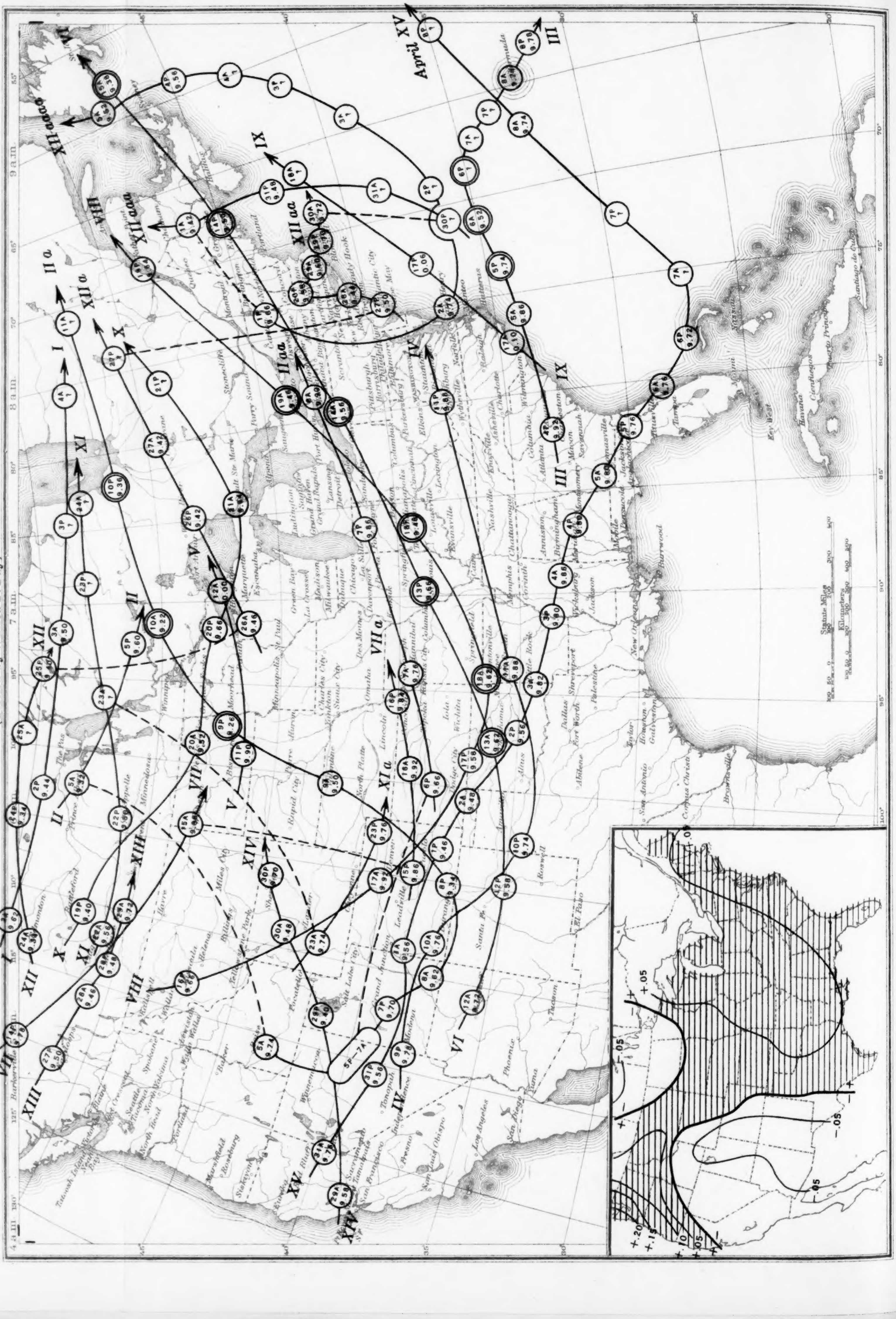

Chart III. Departure (°F.) of the Mean Temperature from the Normal, March, 1925

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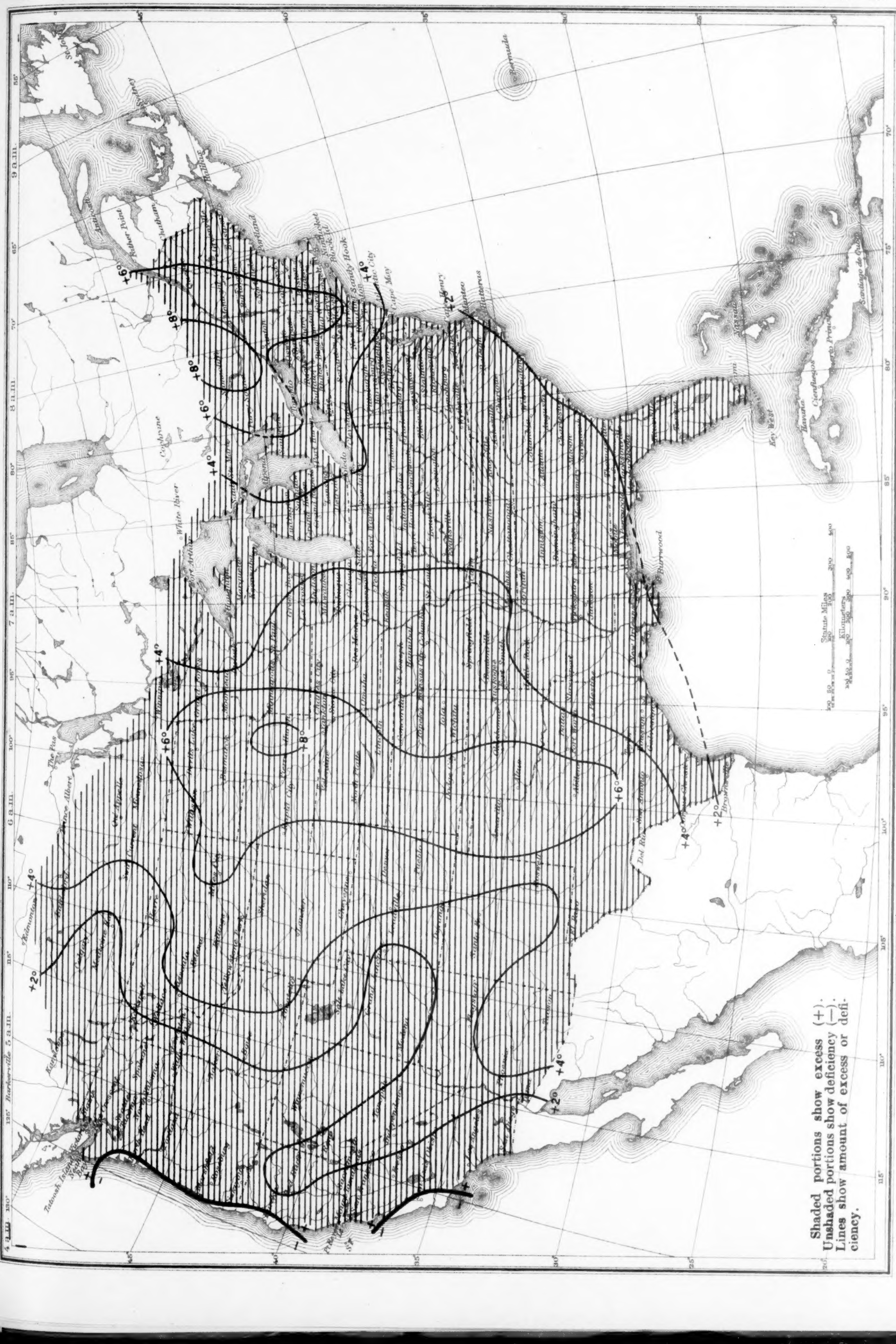

Chart IV. Total Precipitation, Inches, March, 1925. (Inset) Departure of Precipitation from Normal

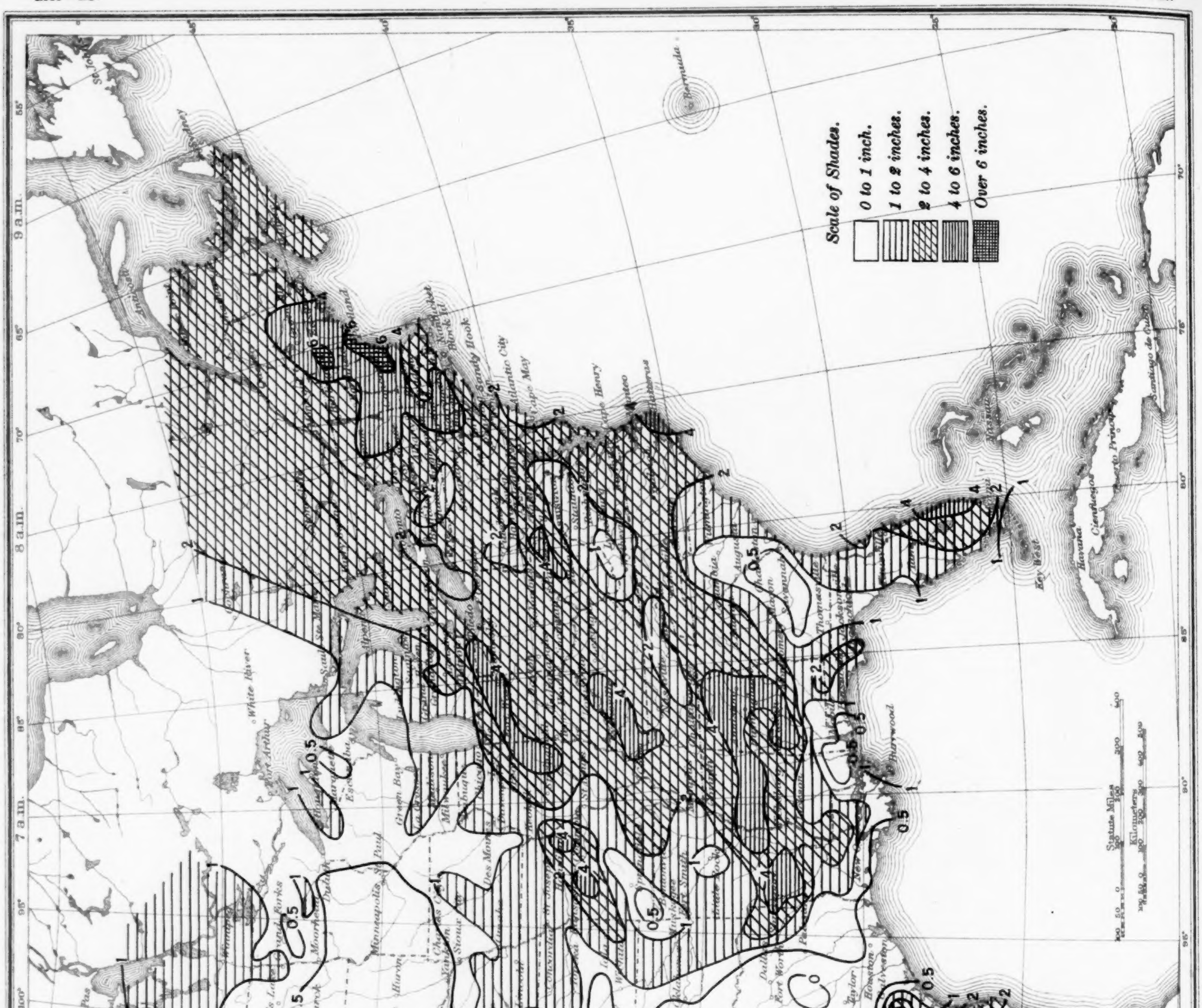

Chart V. Percentage of Clear Sky between Sunrise and Sunset, March, 1925

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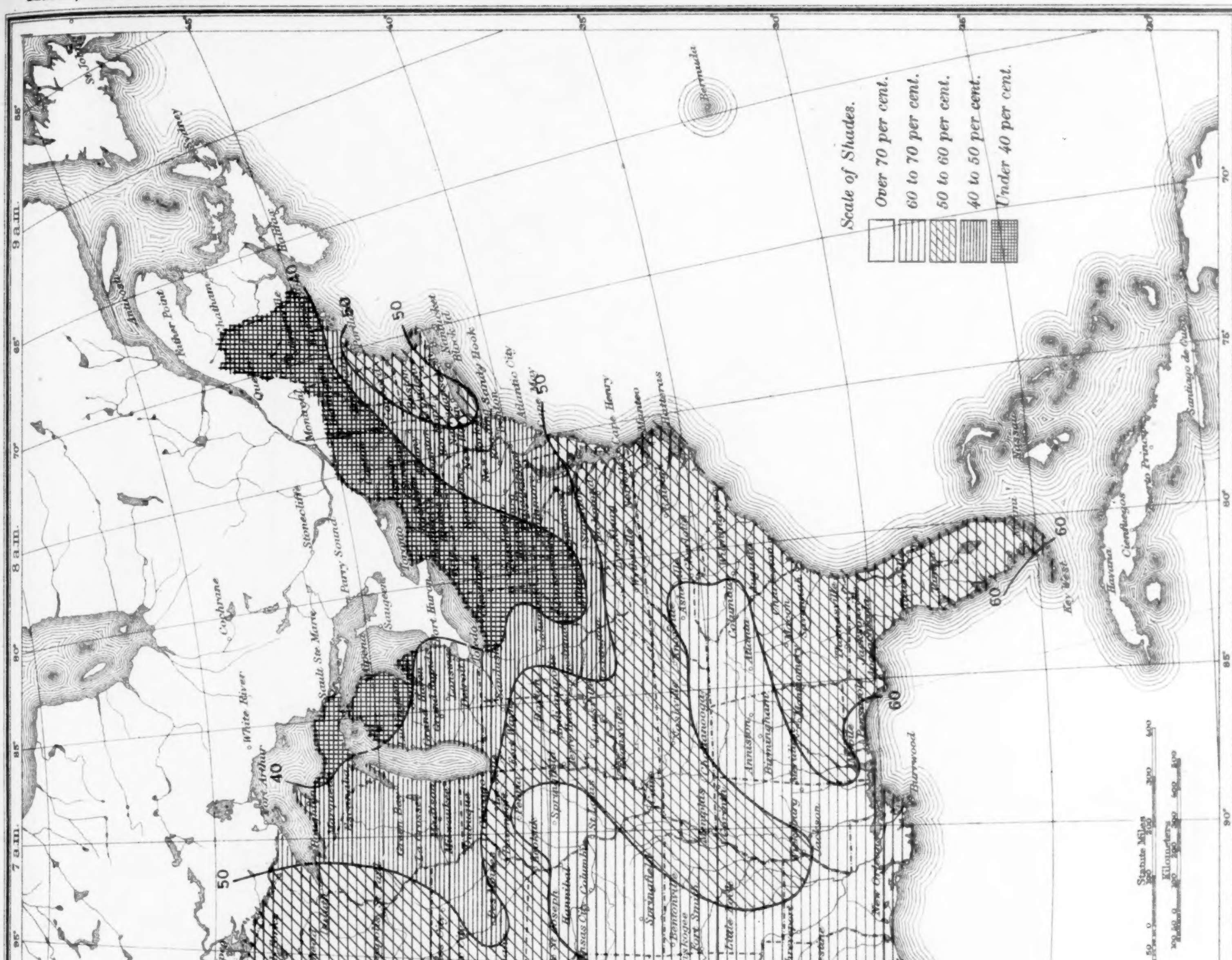

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, March, 1925

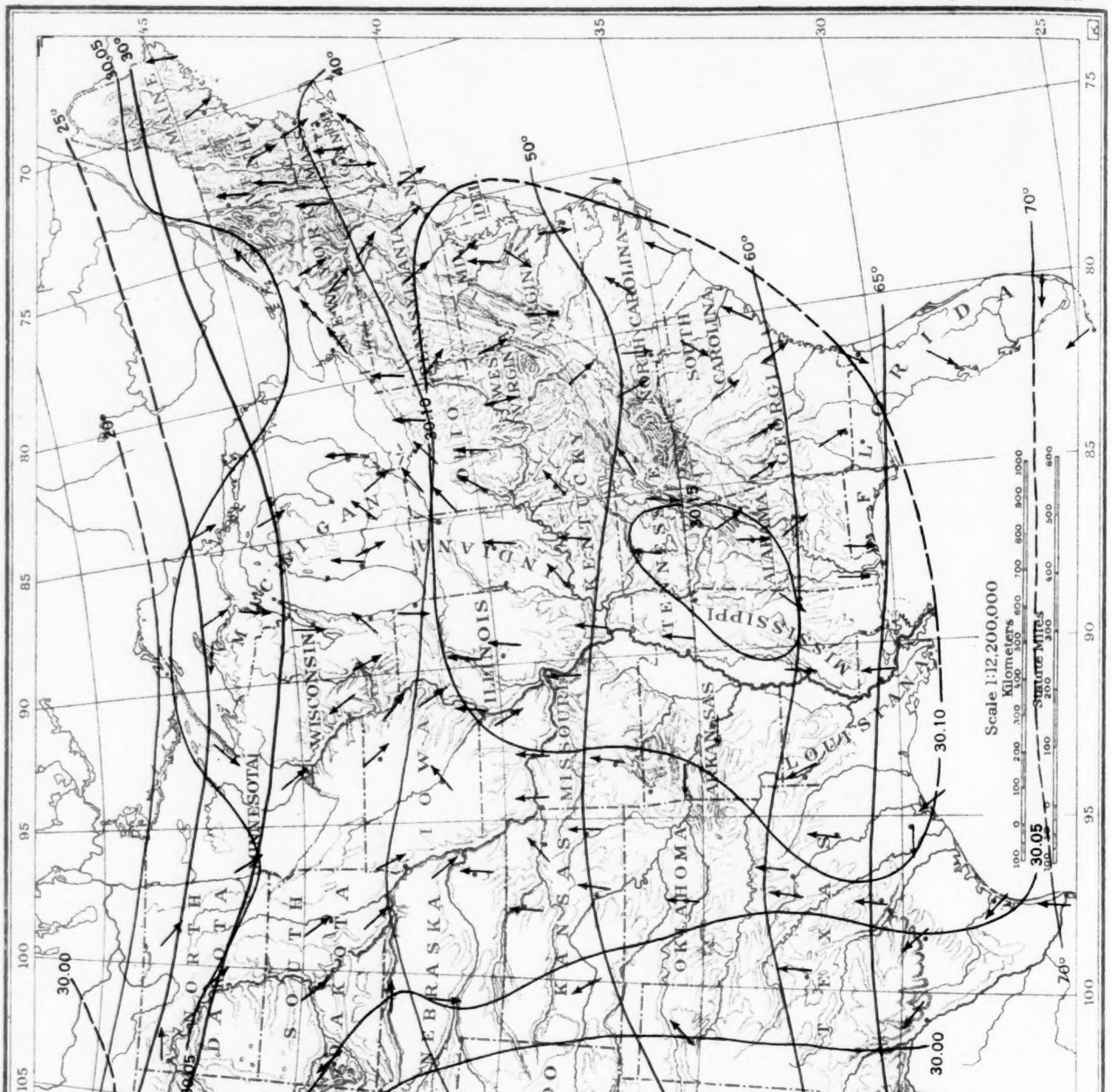

Chart VII. Total Snowfall, Inches, March, 1925. (Inset) Depth of Snow on Ground at end of Month

Chart VII. Total Snowfall, Inches, March, 1925. (Inset) Depth of Snow on Ground at end of Month

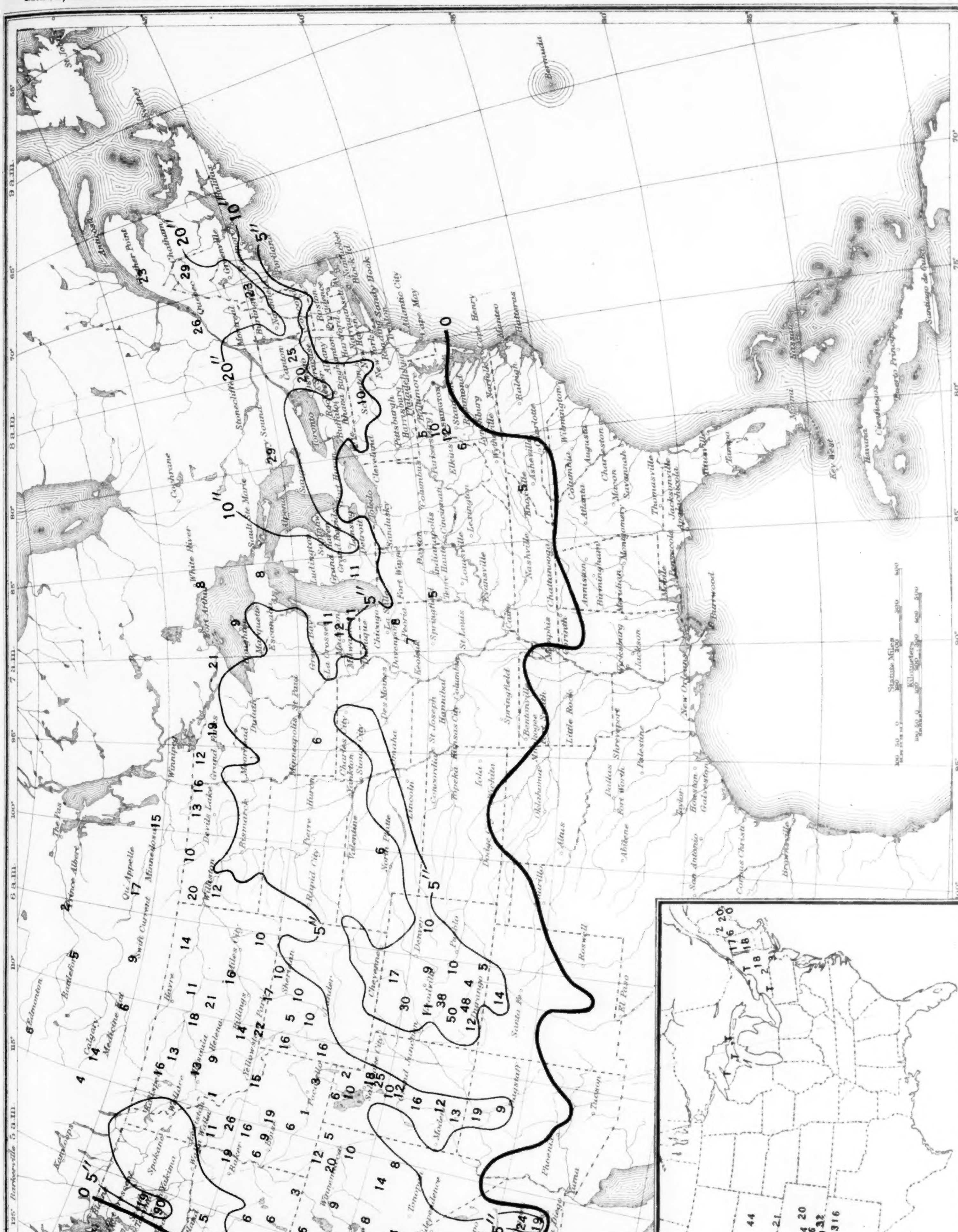

Chart VIII. Weather Map of North Atlantic Ocean, March 11, 1925
(Plotted by F. A. Young)

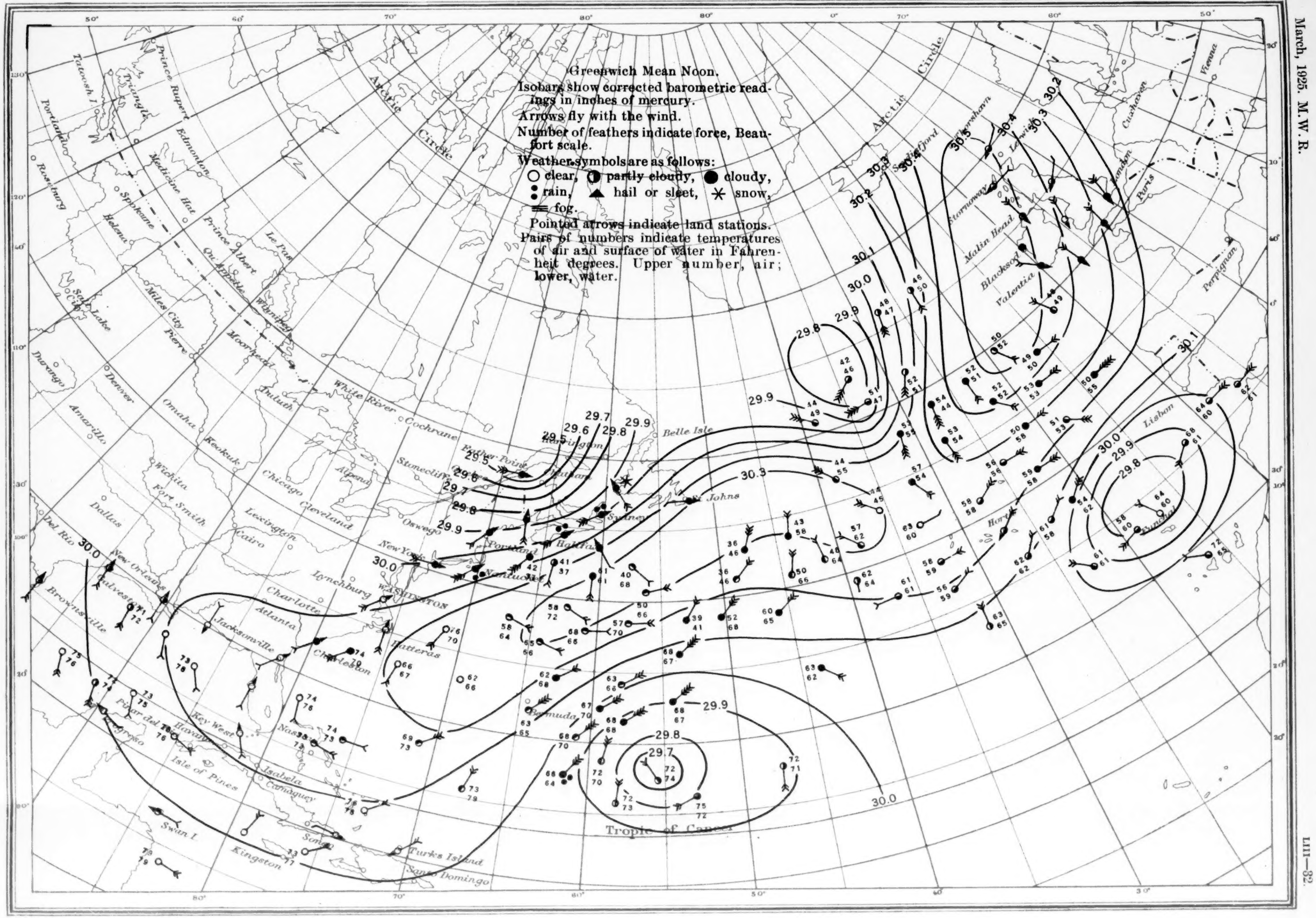

Chart IX. Weather Map of North Atlantic Ocean, March 12, 1925
(Plotted by F. A. Young)

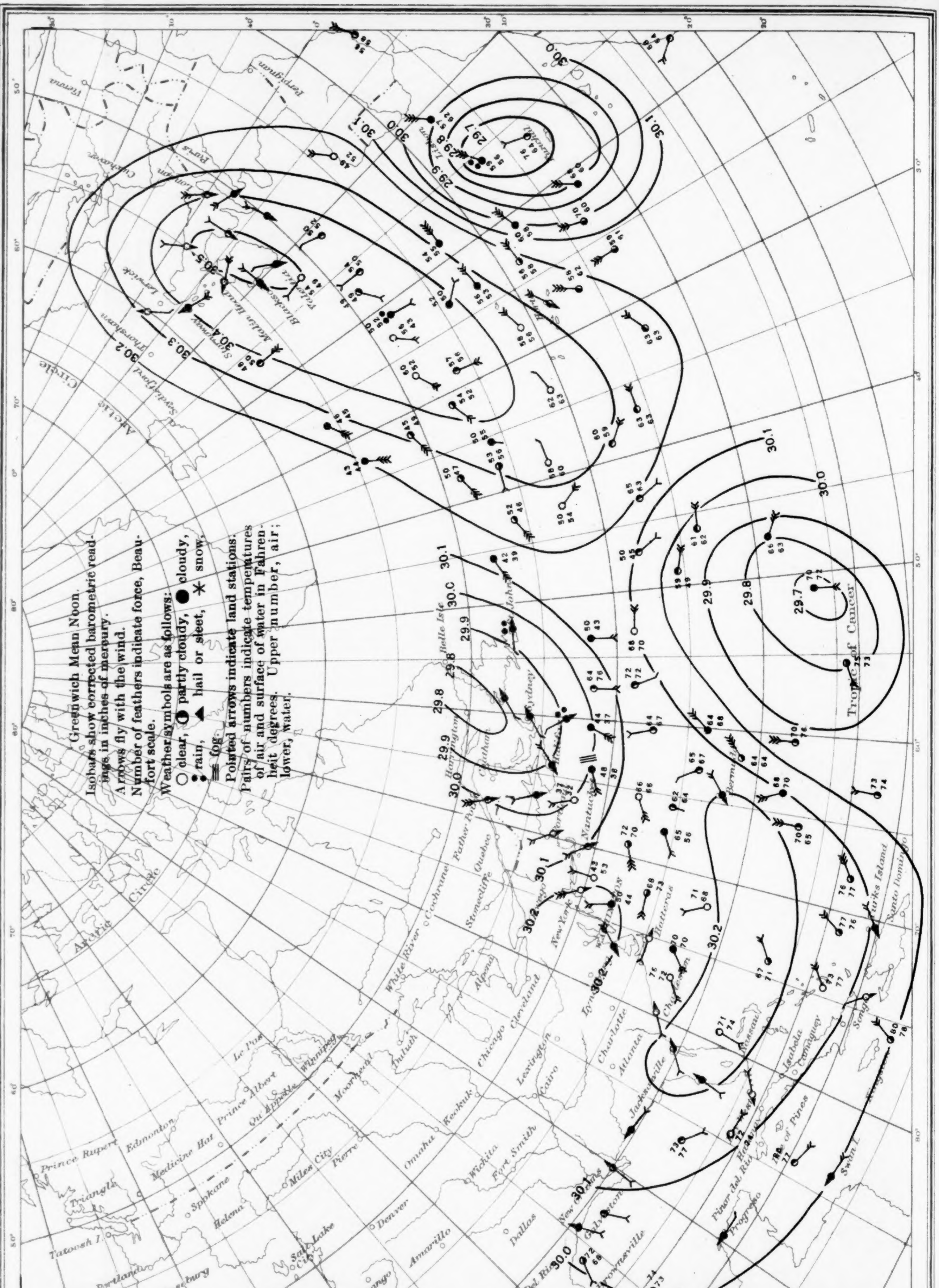

Chart X. Weather Map of North Atlantic Ocean, March 13, 1925

(Plotted by F. A. Young)

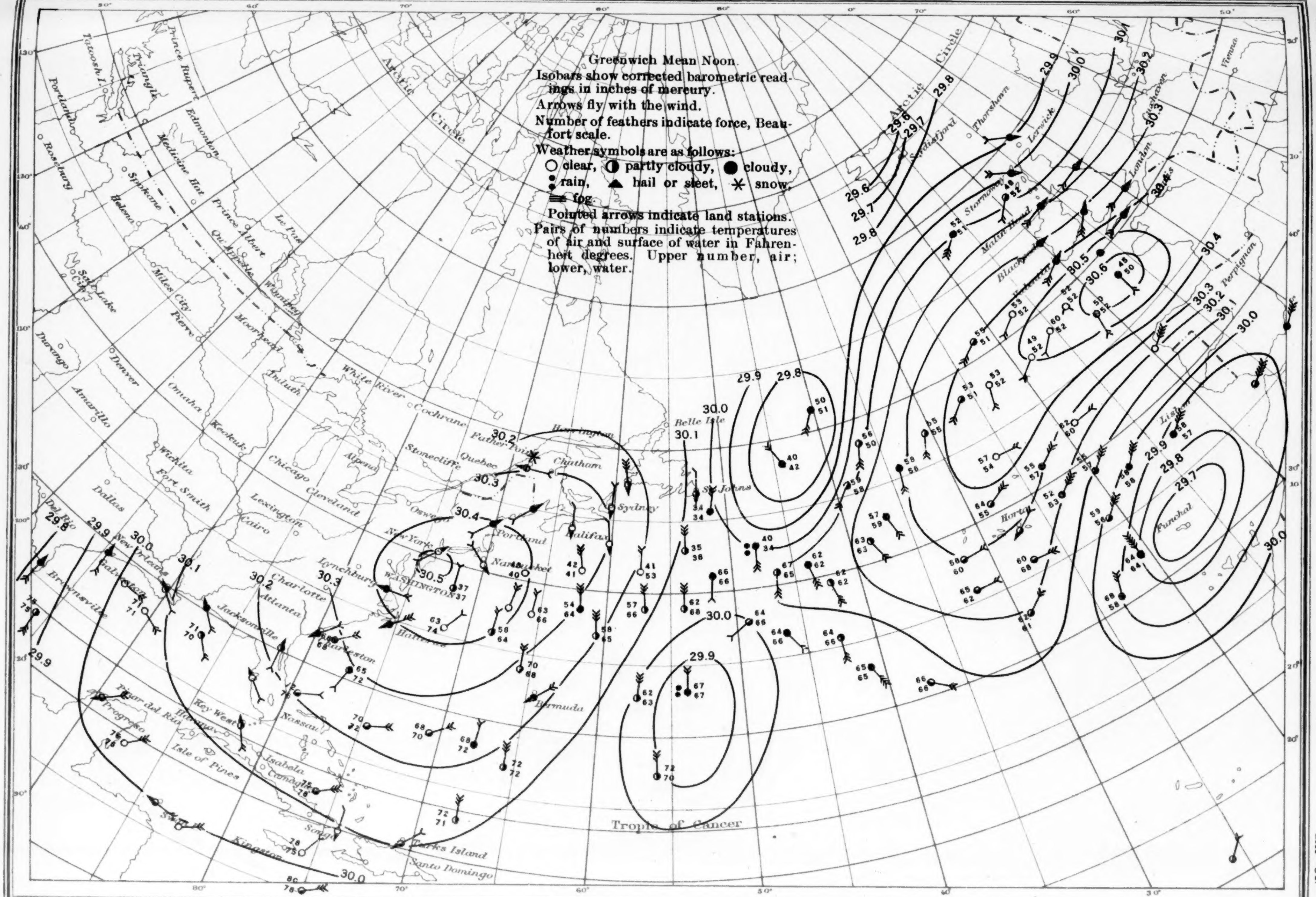

Chart XI. Weather Map of North Atlantic Ocean, March 14, 1925

(Plotted by F. A. Young)

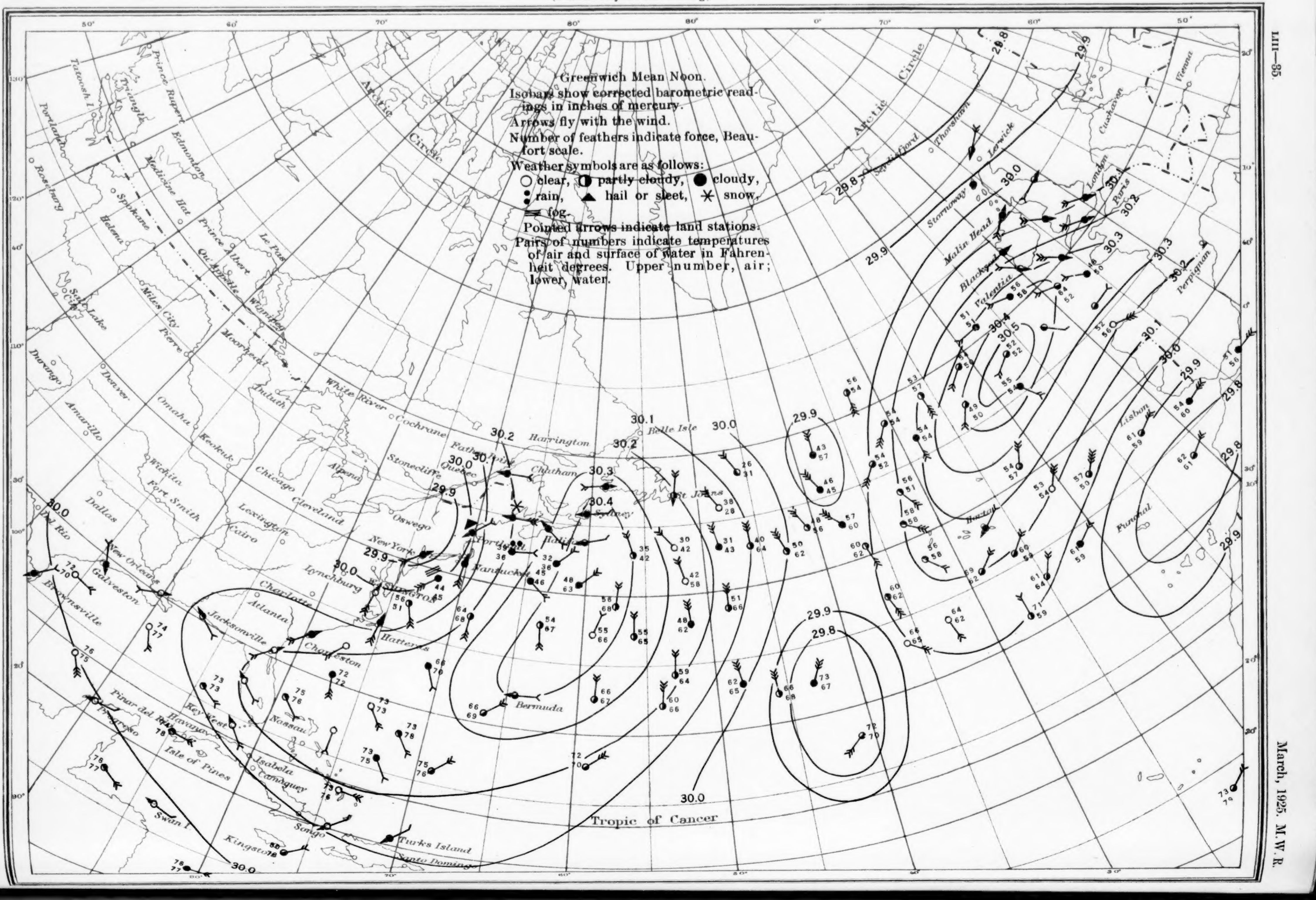

Chart XII. Weather Map of North Atlantic Ocean, March 15, 1925
(Plotted by F. A. Young)

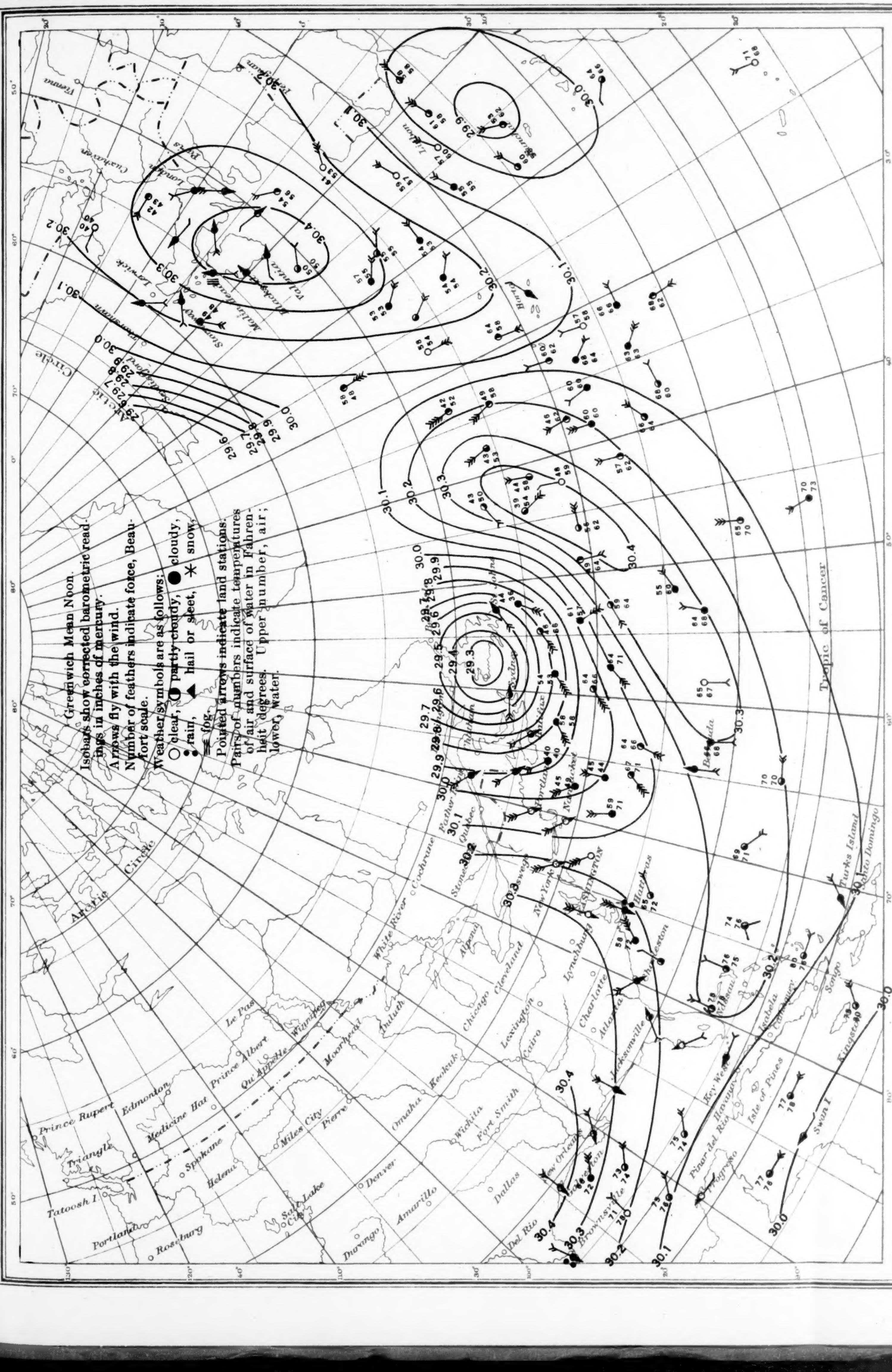

Chart XIII. Weather Map of North Atlantic Ocean, March 16, 1925

(Plotted by F. A. Young)